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THE FINANCIAL RESULTS OF FARMS IN WALES.

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Discussions of the financial position of agriculture are numerous and widespread. Weather conditions, diseases, pests, costs and prices are held responsible by farmers for the unfortunate position of the industry. From other quarters come criticism of the internal conditions of the industry itself and agriculturists are told that their plight is due to their own backwardness and inefficiency. While there may be grounds for both points of view, there must be general agreement that agriculture is passing through a critical period and that farming conditions are far from satisfactory. While the prices of farm produce on the whole average slightly more than in pre-war years, the major items of farm expense are considerably above pre-war costs. Some types of farming have weathered the storm better than others, but the continuous reduction of the workers employed on the land; the agitation for a reduction of rents in some parts of the country and the difficulty of letting some types of farms only point to the fact that farming is not in a prosperous state. While these facts indicate to some extent the prosperity or otherwise of farming the real position can best be judged by the study of the actual records of receipts and expenses on farms. Information of this nature obtained for a number of farms provides some measure of the financial position of farmers in Wales and also affords some indication of the economic situation of some of the main farming types in Wales. The number of farms for which farm accounts have been kept have increased from forty-two in 1929-30 to sixty-eight in 1935-6. But amongst this group of farms, there are twelve for which accounts have been kept regularly since 1929-30. While the material available for the selected group and for all farms throws considerable light on the relative position of the industry over a series of years, no one dealing with a set of accounts of this character would be prepared to state that they provide a fully representative sample of all the farms in Wales in the sense that if all farms were recorded the results would be exactly the same as those of the sample group.

Land Utilisation and Lvestock Carried.
(Group of 12 Farms).

The record of the same twelve farms over the seven years period 1929-30 to 1935-6 will first be dealt with.

The average acreage of these farms is about 118 acres but individually they range from forty-two to 340 acres. The average rent is about 13s. 6d. per acre with a range between 4s. to 39s. per acre. The average size of these farms is slightly higher than the average of all agricultural holdings in Wales and they differ to some extent in the use of land. There is more area under crops and less under hay, while the acreage under permanent pasture and rough grazing is almost exactly the same as that recorded for the whole of Wales. In numbers and classes of livestock as indicated by the *Agricultural Statistics* for Wales, these farms carry a larger number of horses, cattle and pigs and very similar numbers of sheep and poultry per 100 acres. While the group may not represent actual conditions of Welsh farming as a whole the sample does contain farms which are representative of the main farming types in Wales.

Over the whole period, the land was distributed between arable crops, hay, permanent pasture and rough grazings in the following proportions:—Arable crops 11.3 per cent.; hay 15.3 per cent.; permanent grass 35.3 per cent.; and rough grazings 38.1 per cent. Not only have these farms maintained approximately the same area of land but the proportion of arable to grassland remained fairly constant over the whole period. Between one year and another the difference in the area under arable crops is only slightly over 1 per cent. of the total, and the same is true of hay. Some slight changes have taken place in the nature of the cropping but taking corn crops as a whole the difference in acreage between one year and another is very small and this is equally true of the land under " other " crops.

Numbers and classes of livestock have not on the whole shown much variation and some classes of livestock have kept fairly constant in number during the whole period. Work horses averaged about two per 100 acres and varied between 1.9 and 2.2; " other " horses show variations of from 1.0 to 1.5 per 100 acres; dairy cows have averaged about eight or nine per 100 acres and the difference between the lowest and highest number over the seven years was slightly over one cow per 100 acres. " Other " cattle have varied in numbers from 12.5 in 1934-5 to 14.1 per 100 acres in 1930-1. Breeding ewes showed a tendency to increase in number up to about 1932-3 and then to

decline but the variation between one year and another was not so very great; the highest being fifty-five and the lowest forty-three ewes per 100 acres. " Other " sheep varied from forty-five in 1930-1 to twenty-eight per 100 acres in 1934-5. From 1930-1 up to 1934-5 " Other " sheep showed a tendency to decline with a slight recovery in 1935-6. Breeding sows varied between 1.0 and 1.4 per 100 acres, with a tendency to decrease in number from 1929-30 to 1933-4 and with a slight recovery in 1934-5. With " other " pigs the number decreased from 9.5 in 1929-30 to 4.9 per 100 acres in 1932-3, then rose to 6.4 in 1933-4 to remain fairly constant in the following two years. Poultry flocks increased gradually up to about 1934-5, but in 1935-6 there was a slight reduction in the numbers kept. Poultry varied in numbers from sixty-two to ninety-seven per 100 acres.

On the whole, therefore, these farms show only minor differences in the system of cropping and in the number and classes of livestock carried. Thus one would expect that difference in the receipts from these farms would be influenced more by prices of farm products rather than by the number and quantities of farm products sold.

Financial Results.

Briefly the simple results as regards the expenditure, receipts and differences in valuations are shown by these figures :—

Per Farm.

Year.		*Receipts.* £	*Expenses.* £	*Surplus.* £	*Valuation Difference.* £	*Farm Income.* £
1929-30	....	686	519	169	+ 46	213
1930-1	....	628	472	156	+ 22	178
1931-2	....	563	450	113	— 38	75
1932-3	...	512	410	102	— 55	47
1933-4	....	549	443	106	+ 13	119
1934-5	....	609	498	111	+ 34	145
1935-6	...	642	496	146	+ 46	192

Per 100 Acres.

Year.		*Receipts.* £	*Expenses.* £	*Surplus.* £	*Valuation Difference.* £	*Farm Income.* £
1929-30	....	596	451	145	+ 40	185
1930-1	....	547	412	135	+ 20	155
1931-2	..	491	392	99	— 33	66
1932-3	....	438	351	87	— 47	40
1933-4	....	474	383	91	+ 12	103
1934-5	....	490	400	90	+ 26	116
1935-6	....	512	396	116	+ 37	153

Receipts include value of farm produce consumed in the house and rent of farm house at rateable value. Expenses include wages due or paid to family labour. In all years there was a surplus of receipts over expenses but the balance declined from 1929-30 up to 1932-3. Some slight recovery was made in 1933-4

and again in 1934-5 and returns were decidedly better in 1935-6. Valuation differences show a depreciation of capital in 1931-2 and again in 1932-3.

The income from these farms can be further considered in three ways. First there is the *gross (family) income.* This represents the fund from which are drawn wages of family labour, earnings of management by the farmer and also interest on the capital invested in the farm business. Then there is the *farm income* which is the balance remaining after deducting from the gross income the wages of family labour other than that of the farmer and his wife. The *labour income* is calculated by deducting from the farm income an interest charge on the capital invested at 6 per cent. This *labour income* represents the earnings of the farmer and his wife in manual labour and management on the farm.

Per Farm.

Year.	*Gross Income.*	*Farm Income.*	*Labour Income.*
	£	£	£
1929-30	239	213	167
1930-1	210	178	131
1931-2	105	75	29
1932-3	79	47	1*
1933-4	154	119	71
1934-5	173	145	98
1935-6	225	192	148

Per 100 Acres.

Year.	*Gross Income.*	*Farm Income.*	*Labour Income.*
1929-30	208	185	146
1930-1	183	155	114
1931-2	92	66	25
1932-3	67	40	1*
1933-4	133	103	64
1934-5	139	116	79
1935-6	179	153	114

* Nearest £.

This group of twelve farms on the whole have throughout the period been able to show farm income and labour income, but the amounts have varied considerably from year to year; they reflect the general trend of prices of agricultural products. In the year 1929-30 the average farmer's earnings amounted to nearly 82s. per week and allowing 6 per cent. on capital invested his earnings as an operative manager were about 64s. per week. By 1931-2 the farmer's total earnings had dropped to about 29s. per week and managerial earnings to 11s. per week. Conditions were still worse in 1932-3, with farmer's total earnings at something like 18s. per week and practically no labour income. Some recovery was made in 1933-4 and conditions improved up to 1935-6 when in that year the total earnings of the farmer stood at nearly 74s. per week and his earnings as an operative manager

at 55s. per week. The financial position of the farmer as revealed by the average returns for this group of farms was therefore approaching that which existed in 1929-30.

Total Group of Accounted Farms.

We may now consider the result of all the farms for which records have been obtained. The variations in number and average size of the farm from year to year are as follows :—

Year	*Farms. No.*	*Average Size Acres.*
1929-30	42	143
1930-1	54	146
1931-2	61	145
1932-3	68	152
1933-4	62	160
1934-5	65	148
1935-6	68	160

Financial Results (All Types).

Receipts, expenses and valuation differences for all farms are herewith stated.

Per Farm.

Year.	*Receipts.* £	*Expenses.* £	*Surplus* £	*Valuation Difference.* £	*Farm Income* £
1929-30	783	639	142	+ 39	181
1930-1	746	629	127	+ 21	148
1931-2	714	645	69	— 27	42
1932-3	667	615	52	— 46	6
1933-4	766	682	84	+ 16	100
1934-5	1,058	925	133	+ 33	166
1935-6	1,125	1,002	123	+ 104	227

Per 100 Acres.

Year.	*Receipts.* £	*Expenses.* £	*Surplus* £	*Valuation Difference.* £	*Farm Income* £
1929-30	547	446	101	+ 25	126
1930-1	501	431	70	+ 31	101
1931-2	492	444	48	— 19	29
1932-3	440	406	34	— 30	4
1933-4	480	427	53	+ 10	63
1934-5	715	625	90	+ 22	112
1935-6	701	624	77	+ 52	129

The actual cash position as revealed by the returns for this group show on the whole lower cash balance than for the small group of twelve farms which cover the same period.

When again the farm income is considered, this group shows lower returns but the position per farm is better in 1934-5 and 1935-6 than for the smaller group. When, however, the groups are compared on a per 100 acres basis the smaller group shows a better farm income over the whole period.

Per Farm.

Year.	Gross Income.	Farm Income.	Labour Income.
	£	£	£
1929-30	234	181	124
1930-1	192	148	87
1931-2	88	42	— 24
1932-3	46	6	— 55
1933-4	141	100	38
1934-5	203	166	91
1935-6	251	207	129

Per 100 Acres.

Year.	Gross Income.	Farm Income.	Labour Income.
1929-30	163	126	87
1930-1	131	101	60
1931-2	61	29	— 16
1932-3	30	4	— 36
1933-4	88	63	24
1934-5	137	112	62
1935-6	156	129	81

The average farmer's earnings for this group dropped in each year from nearly 70s. per week in 1929-30 to about 2s. per week in 1932-3 and then increased each year to nearly 80s. per week in 1935-6. When interest was allowed on capital at 6 per cent. per annum the average farmer as manager earned nearly 48s. per week in 1929-30, and about 33s. in the next year and failed to earn interest on his capital in 1931-2 and 1932-3. In the next year his managerial earnings averaged between 14s. and 15s. per week, then increased in the following year to 35s. and in the last year (1935-6) reached nearly 50s. per week.

The analyses of both these groups of farm accounts, that for the whole group of unselected accounts as collected and for the small group of twelve farms agree in showing the very low financial position of farmers in 1931-2 and 1932-3 and a gradual recovery in 1933-4 which continued up to 1935-6.

The price changes that have occurred during 1929-36 varied widely for different farm products and farm incomes would be largely determined by the price of the commodities the farmer had to sell. In the case of these farms, the chief sales are of livestock and livestock products but the proportion of sales of sheep, cattle, pigs, dairy produce, etc., varied according to the system of farming pursued. For that reason, the general group of farms is divided into type-groups which are fairly representative of the main farming types in Wales. The classification of the type-groups is done on the basis of the knowledge of the farms together with examination of the sources of receipts. While the limitations of the results for the type-groups are fully recognised, they do nevertheless provide some basis of comparison as between one farm type and another and indicate the

relative financial position of different groups of farms over a series of years. Classification by type of farms is as follows :—

Cattle and Sheep (Poor Land).
Cattle and Sheep (Better Land).
Mixed Farms.
Cattle and Milk.

In the case of the *Cattle and Sheep (Poor Land)* farms, the group incomes tend to be low over the whole period for they have been seriously affected by the drop in prices for store sheep, store cattle and butter which started in 1931, and while market conditions were decidedly better in 1935-6 prices were still below those obtained during 1929-30. The years 1931-2 and 1932-3 showed very poor returns and no farm income was obtained. Even with some improvement in prices this group only showed a farm income of £102 and a labour income of £34 per farm in 1935-6 which was about one-half the farm income and about one-quarter the labour income obtained in 1929-30.

The *Cattle and Sheep (Better Land)* group have also shown small incomes during the seven years and particularly during the period 1931 to 1935. There was no farm income during the years 1931 to 1935. Owing to the greater reliance on cattle and the continued low price of cattle, this group has suffered depression longer than the other type-groups. Returns for this group were decidedly better in 1935-6 with a farm income of £186 and a labour income of £98 per farm, and returns were even better than those obtained in 1929-30.

The *Mixed Farms* group show that incomes declined in 1931-2 and the group failed to show a farm income in the next year and only a farm income of £6 per farm in 1933-4. Conditions improved considerably in 1934-5 when a farm income of £225 and a labour income of £155 was obtained. In 1935-6 this group dropped in farm income to £137 and in labour income to £64 per farm. The low prices ruling for pigs and the decline in the prices of poultry, eggs and butter seriously affected the incomes for this group from 1931 to 1933.

With the exception of 1932-3 the *Cattle and Milk* farms as a whole obtained real incomes in all years, and while incomes decreased from 1929-30 to 1932-3, recovery was made in 1933-4 and continued up to 1935-6. The financial returns, however, in that year were not quite as satisfactory as those obtained in 1929-30 when the farm income averaged £297 and the labour income £236 as against £279 and £200 per farm in 1935-6.

TABLE I.

Gross Income, Farm Income and Labour Income.
(Per Farm and per 100 Acres).

Cattle and Sheep (Poor Land).

Year	*Number of Farms.*	*Average Size.*	*Per Farm.* *Gross Income.*	*Per Farm.* *Farm Income.*	*Per Farm.* *Labour Income.*	*Per 100 Acres.* *Gross Income.*	*Per 100 Acres.* *Farm Income.*	*Per 100 Acres.* *Labour Income.*
		Acres.	£	£	£	£	£	£
1929-30 . . .	15	234	259	187	127	110	80	54
1930- 1	15	246	201	137	67	82	56	27
1931- 2 . ..	16	260	60	11*	84*	23	4*	32*
1932- 3	17	299	2	53*	110*	1	18*	37*
1933- 4	16	304	132	81	26	44	27	9
1934- 5.. ...	12	234	127	75	21	51	32	9
1935- 6.......	11	285	170	102	34	60	36	12
Average (7 years)		267	132	70	7	40	26	3

Cattle and Sheep (Better Land).

		Acres.	£	£	£	£	£	£
1929-30	6	131	216	160	93	165	122	71
1930- 1. . ..	17	117	211	167	112	191	152	101
1931- 2 .	16	119	16	24*	86*	13	20*	72*
1932- 3	15	109	33	6	45*	30	5	41*
1933- 4 . .	12	116	38	0	51*	32	0	45*
1934- 5	17	157	104	69	7*	67	44	4*
1935- 6	13	213	247	186	98	116	87	46
Average (7 years)		136	115	74	10	85	54	7

Mixed Farms.

		Acres.	£	£	£	£	£	£
1929-30	10	79	105	55	12	134	70	16
1930- 1........	9	81	110	79	20	135	97	25
1931- 2..	14	78	84	28	29*	109	36	37*
1932- 3.	12	84	13	42*	102*	15	50*	122*
1933- 4	11	78	70	6	48*	90	8*	63*
1934- 5..	10	81	276	225	155	342	280	193
1935- 6........	12	102	159	137	64	156	134	63
Average (7 years)		83	113	66	6	135	79	7

Cattle and Milk Farms.

		Acres.	£	£	£	£	£	£
1929-30	11	85	326	297	236	385	351	280
1930- 1.......	10	114	220	192	136	193	168	120
1931- 2..... .	18	119	119	167	97	159	140	82
1932- 3.	24	107	102	73	2	95	68	2
1933- 4........	23	125	235	211	134	189	169	107
1934- 5...... ..	26	128	274	249	171	214	195	134
1935- 6..	32	118	314	279	200	266	236	169
Average (7 years)		115	238	210	137	206	182	119

* Minus quantities.

Over a seven year period the average incomes earned were as follows :—The *Cattle and Sheep* (*Poor Land*) group showed a gross incom of £132, a farm income of £70 and a labour income of £7 per farm, the *Cattle and Sheep* (*Better Land*) group showed a gross income of £115, a farm income of £74 and a labour income of £10 per farm, the *Mixed Farms* group showed a gross income

of £113, a farm income of £66 and a labour income of £6 per farm, and the *Cattle and Milk* farms showed a gross income of £238, a farm income of £210 and a labour income of £137 per farm. In the cases of both *Cattle and Sheep* groups (*Poor Land and Better Land*) and the *Mixed Farms*, the average farmer was earning less than a farm labourer paid at minimum Wages Board rates but on the *Cattle and Milk* farms the average farmer's earning was slightly over £4 per week.

Changes in Receipts and Expenditure.

The causes of these changes in the farmer's financial position which have been described cannot be reasonably attributed to the farming circumstances of a particular year but rather to the difficulty which farmers have experienced in keeping their organisation adjusted to rapidly changing levels of prices and costs. The nature of farming is such that farming methods or systems cannot be immediately changed to meet changes in market demand. The price changes that have occurred have varied widely for different commodities and demand for products did not all show the same changes. While farmers' incomes are influenced by changes in unit prices they are also influenced by the type and quantity of the produce which they sell, but for a group of farms which show practically no change in acreage, in the cropping, or any appreciable change in the stocking it is possible to have a fairly accurate indication of the actual changes in prices and of changes in receipts and expenditure. For the group of twelve farms, changes in land utilisation have been negligible and the actual changes in the number and classes of livestock have not been very great. Practically the only changes in stocking likely to affect the sales were the slight decline in the number of pigs and sheep other than ewes and some increases in the poultry flocks

Table II shows each item of yearly receipts for the group of twelve farms as a percentage for the item in 1929-30.

For the period under review there was a depression in prices of all classes of cattle and especially in the store cattle trade. For the group of twelve farms, the figures indicate that for about the same number of cattle produced and sold for £100 in 1929-31 only about £75 was received in 1935-6. Butter prices fell very rapidly and receipts for these farms in 1934-5 and 1935-6 were about 64 per cent. below those of 1929-30, but in these two years there was some change over from the sale of butter to sale of milk, and this influenced receipts to some extent. Receipts by

milk fell in 1930-1, then continued fairly steadily in the next three years and increased in the last two years. Yields of sales of sheep fell heavily from 1930-1 and in 1933-4 were only about 70 per cent. of those in 1929-30 and while some improvement was made in the next two years, receipts were about 23 per cent. below those of 1929-30. Receipts from pigs showed a reduction of 45 per cent. in 1930-1 and 59 per cent. in the next

TABLE II.

Percentage Increase or Decrease in Receipts.

(Group of Twelve Farms).

(Base 1929-30 = 100).

Year.	1930–1	1931–2	1932–3	1933–4	1934–5	1935–6
Cattle	101.3	98.2	71.1	75.1	84.5	75.5
Butter	81.0	71.5	54.7	40.7	36.5	36.4
Milk	96 6	81.6	80.8	81.4	98.7	113.9
Cheese	77.6	66.9	43.7	46.0	37.4	15.6
Cream	—	—	100.0	115.8	53.6	31.6
Total Dairy Produce	92.5	79.0	79.5	77 2	85 4	95.3
Sheep and Wool	101.2	88.6	71.6	69.8	71 1	76 8
Pigs	54.7	41.0	40.9	58 8	52.6	63.2
Poultry and Eggs	114.8	127.4	114.1	122.7	111.8	112.2
Horses	91.5	68.8	79.5	145.1	122.2	108.6
Total Livestock and Livestock Products	91.6	81.7	71 6	77.0	80.1	83 1
Crops	93.4	88.3	94.4	90.8	96.5	94.7
Sundries	101.7	121.5	213.4	289.3	248.2	331.6
Total Receipts	91.8	82.3	73.5	79.6	82.1	85.9

year, then continued very much the same in the following year and increased to some extent in the next three years, and sales in 1935-6 were about 37 per cent. below those in 1929-30. Although there was a decrease in prices, the sales of poultry and eggs on the whole increased as flocks became larger up to 1933-4 and then declined the next two years. Receipts by livestock and their products in the year of heavy depression were 28 per cent. below those of 1929-30 and in 1935-6 they still remained 17 per cent. below the standard figure. When they reached the lowest point in 1932-3 total receipts were about 26 per cent. below standard but showed improvement up to 1935-6 when in that year they were 14 per cent. below the standard adopted.

There has been an attempt to meet falling prices by reducing expenditure. Rents showed very little change. The slight increases or reductions that did occur were due to the adding or releasing of small areas of land. In some cases during the period

1934 to 1936 small concessions in rent were made by landlords to lighten the burdens of their tenants. Expenditure on hired labour, with the exception of 1933-4, declined each year and the reduction amounted to nearly 20 per cent. in 1935-6. Expenditure on family labour was variable but on the whole higher; except in 1933-4 expenditure on total labour declined, and in 1935-6 was about 12 per cent. below the amount paid in 1929-30. There was a reduction in expenditure on feeding stuffs in the first four years, and while this can be attributed in part to the fall in prices of cakes and meals there was definitely a reduction

TABLEL III.

Percentage Increase or Decrease in Expenses and Capital.

(Group of Twelve Farms).

Base 1929-30 = 100).

Year	1930-1	1931-2	1932-3	1933-4	1934-5	1935-6
Rent	101.4	100.7	102.5	102.1	99.5	98.7
Rates	90.4	81.4	69.0	58.4	57.1	49.5
Wages (Hired)	95.7	95.5	88.7	93.0	83.0	80.7
Wages (Family)	126.2	111.8	120.8	134.7	101.4	115.4
Total Labour	101.9	99.4	95.3	101.6	86.8	87.8
Feedingstuffs	82.9	84.1	79.0	85.6	92.2	86.0
Manures	107.9	74.7	45.3	54.1	60.9	87.0
Seeds	192.0	187.4	117.9	113.3	87.2	151.2
Implements and Repairs	63.1	141.7	158.8	136.6	74.9	47.5
Sundries	74.3	72.9	54.5	65.6	87.8	119.6
Horses bought	107.9	146.8	120.1	151.2	219.7	193.6
Cattle bought	62.3	54.4	39.5	60.4	79.8	69.3
Sheep bought	105.5	67.4	46.3	39.6	64.1	74.0
Pigs bought	91.8	79.6	55.5	162.1	134.4	62.0
Poultry and Eggs for Hatching	606.2	238.7	628.7	467.5	853.9	317.0
Total Livestock bought	82.5	67.3	49.8	64.6	88.7	78.6
Total Expenses	91.3	87.0	77.8	84.9	88.7	87.7
Total Capital	104.0	103.0	92.0	97.8	94.0	98.0

in the quantities bought during the years 1931 to 1933. In the last three years purchases of feedingstuffs were fairly well maintained. While the drop in prices of fertilisers is to some extent responsible for the decrease in the expenditure on manures it is fairly clear that in some years less fertilisers were used. The fact that expenses incurred in 1932-3 were about 55 per cent. and in 1933-4 about 46 per cent. below those in 1929-30 clearly show that an attempt was made to curtail expenditure in that direction. Expenditures on seeds are variable. They increased considerably in the first two years, then dropped and were in 1934-5 about

18 per cent. below those in 1929-30. They increased again in 1935-6 and were 51 per cent. above expenses incurred in 1929-30. Purchases of implements and repairs, which is a small item, increased during the years 1931 to 1934. Other years showed reductions. Total livestock purchases show reduction. This is partly accounted for in the drop in prices and partly in the number bought. When total expenses are considered these fell by nearly 9 per cent. in the first year, 13 per cent. in the second year, and by 22 per cent. in the third year. In the following years they varied between 11 and 15 per cent. below those in 1929-30. The details are given in Table 3.

Expenditure on purchase of livestock and cost of labour appear to be of nearly equal importance in the farm expenses and together account for about 50 per cent. of the farm costs in each year. The proportion of rent. to total expenses varied from about

TABLE IV.
Percentage Composition of Expenses.
(Group of Twelve Farms).

Year.	1929-30	1930-1	1931-2	1932-3	1933-4	1934-5	1935-6
Rent	14.91	16.55	17.24	19.65	17.94	16.71	16.77
Rates	1.51	1.50	1.42	1.34	1.04	0.97	0.85
Wages (Family)	19.21	20.12	21.09	21.93	21.06	17.96	17.67
Wages (Hired)	4.98	6.88	6.57	7.73	7.91	5.69	6.55
Total Labour	24.19	27.00	27.66	29.66	28.97	[illegible]	24.22
Feeding stuffs	19.38	17.60	18.74	19.69	19.55	20.11	19.01
Manures	3.10	3.66	2.67	1.81	1.98	2.08	3.11
Seeds	1.15	2.41	2.47	1.73	1.53	1.12	1.97
Implements	2.04	1.41	3.32	4.15	3.28	1.72	1.10
Sundries	6.52	5.30	5.46	4.57	5.04	6.44	8.63
Total Direct Expenses	72.80	75.43	78.99	82.60	79.33	72.8[illegible]	75.66
Horses	2.16	2.55	3.64	3.33	3.84	5.[illegible]4	4.75
Cattle	14.92	10.18	9.32	7.57	10.61	13.[illegible]	11.01
Sheep	9.20	10.64	7.13	5.48	4.29	6.6[illegible]	7.78
Pigs	0.87	0.87	0.80	0.62	1.66	1.[illegible]	0.62
Poultry	0.05	0.33	0.13	0.40	0.27	0.17	0.18
Total Livestock	27.20	24.57	21.02	17.10	20.67	27.17	24.34
Total Expenses	100.00	100.00	100.00	100.00	100.00	100.00	100.00
	£ s d	£ s d	£ s. d.	£ s. d	£ s. d	£ s d	£ s. d.
Total Expenses (Per Farm)	518 13 8	472 8 7	449 18 11	409 12 3	442 15 5	498 [illegible] 8	496 9 0
Total Expenses (Per 100 Acres)	451 0 1	411 19 7	392 7 4	350 17 2	382 15 4	400 8 5	395 16 2

15 to 19 per cent. and cost of feedingstuffs varied between 18 to nearly 22 per cent. Total expenses averaged between one year and another from about 61s. to 90s. per acre.

The relative importance of receipts from sales of various products do provide some indication of the relative importance of the different farm products in the financial position of these

farms. These proportions will of necessity change with prices and with the quantities produced.

The figures set out in Table V show very clearly the importance of cattle, dairy products and sheep in the financial condition of these farms. Cattle and dairy products together represent about 50 per cent. of farm receipts. Sales of cattle consist mainly of store or milking and breeding stock with a very small proportion of fat stock, and sales of dairy produce consist mainly of

TABLE V.

Percentage Composition of Receipts.
(Group of Twelve Farms).

Year.	1929–30	1930-1	1931–2	1932–3	1933–4	1934–5	1935–6
Cattle	23.99	26 48	28 65	23 21	22 64	24.71	21.13
Butter	7.79	6.88	6.77	5 80	3.99	3.47	3 31
Milk	22.47	23.65	22 30	24 69	22.98	27.02	29 84
Cheese	0.15	0.13	0 13	0 09	0 09	0.07	0 03
Cream	—	—	—	2.30	2 46	1.00	0 62
Total Dairy Produce	30 41	30.66	29.20	32 88	29.52	31 6[illegible]	33.80
Sheep and Wool	18.87	20.79	20 31	18 36	16.56	16.33	16.88
Pigs	14.67	8.75	7.31	8 16	10.85	9.41	10 82
Poultry and Eggs	4.45	5.57	6.89	6 91	6.86	6 06	5 82
Horses	3.81	3.79	3.19	4 11	6.94	5 67	4 82
Total Livestock and Livestock Products	96.2	96.04	95.5	93.63	93.37	93 84	93 27
Crops	2.88	2 94	3 09	3 70	3.29	3 38	3 18
Sundries	0.92	1.02	1.36	2 67	3 34	2.78	3.55
Total Receipts	100.00	100.00	100 00	100.00	100.00	100.00	100 00
	£ s d	£ s. d	£ s d	£ s d	£ s. d.	£ s d	£ s d.
Total Receipts (Per Farm)	685 15 3	627 10 10	562 11 10	511 17 7	548 16 9	609 2 2	642 3 0
Total Receipts (Per 100 Acres)	596 5 9	547 4 10	490 12 0	438 9 1	474 9 2	489 11 6	511 19 5

PRODUCE CONSUMED (already included in Receipts).

	1929–30	1930-1	1931–2	1932–3	1933–4	1934–5	1935–6
Per Farm	45 0 1	35 11 6	42 16 4	[illegible]9 10 2	39 15 6	36 2 9	[illegible] 14 8
Per 100 Acres	39 2 8	31 0 5	37 6 9	[illegible] 16 10	34 7 8	29 0 11	29 5 9

milk. Sheep and wool again are fairly important and average from about over one-fourth to one-sixth of total sales. Other items of livestock sales are of less importance. The depressed state of the cattle and sheep market and especially of the store stock trade has influenced the returns for these farms considerably. Prices of store cattle continued to fall up to the beginning of 1935, but some recovery was made during 1935-6. Store sheep have recovered from the low prices of 1932-3, and in 1935-6 were slightly above pre-war prices. Wool prices have been low, but there has been general improvement since 1931-2, when they stood

at less than one-half of pre-war prices. All grades of pigs have recovered to some extent from the low prices of 1932-3 up to 1934-5, but prices of porkers and stores showed a downward trend in the next year. Prices of poultry and eggs continued to fall up to 1934-5, but there was some improvement in egg prices

TABLE VI.

Percentage Increase or Decrease in Receipts.
(All Farms).
(Base 1929-30 = 100).
(Per 100 Acres).

Year.	19[illegible]	1931–2	1932–3	1933–4	1934-5	1935–6
Cattle	108.5	107.4	81.2	76.9	119.8	118.2
Dairy Produce	62.3	74.4	88.6	93.9	122.6	129.4
Sheep and Wool	[illegible]	87.9	64.4	73.6	105.3	110.2
Pigs	10[illegible]	62.7	57.9	81.9	139.1	131.8
Poultry and Eggs	13[illegible]	165.3	161.4	183.4	247.8	233.1
Horses	95.1	94.2	59.3	98.1	128.7	126.7
Total Livestock and Livestock Products	94.6	88.5	79.6	87.5	126.5	127.4
Crops and Sundries	77.3	112.1	92.8	89.3	195.2	139.7
Total Receipts	91.7	89.9	80.4	87.6	130.7	128.2

TABLE VII.

Percentage Increase or Decrease in Expenses and Capital.
(All Farms).
(Base 1929-30 = 100).

Year.	1930–1	1931–2	1932–3	1933–4	1934–5	1935–6
Rent	106.1	121.1	114.6	108.0	140.7	136.3
Rates	83.3	75.6	80.0	70.2	77.1	77.1
Wages (Hired)	86.7	92.5	90.8	90.7	114.4	116.6
Wages (Family)	81.1	85.7	70.9	68.4	66.4	72.7
Total Labour	84.9	90.4	84.6	83.8	99.5	102.9
Feedingstuffs	86.2	90.2	104.1	114.8	189.4	171.9
Manures	72.0	60.7	54.0	54.6	73.7	75.7
Seeds	100.5	75.3	72.7	46.2	65.3	70.7
Implements	91.4	136.2	131.7	108.8	177.9	164.9
Sundries	62.8	75.1	79.1	80.2	140.0	165.6
Livestock bought	130.7	118.2	77.7	93.7	161.2	165.3
Total Expenses	96.6	99.5	90.9	95.5	140.0	139.9
CAPITAL.						
Livestock	111.1	114.9	99.8	96.8	120.4	122.6
Crops	85.8	118.7	110.5	104.2	114.7	118.1
Stores, Implements, &c.	91.0	108.1	101.8	102.4	129.5	121.9
Average Capital	104.1	113.9	101.3	98.8	121.7	122.0

in the following year. Milk prices have improved continuously since 1931-2. Prices of butter and cheese, particularly the former, have continued to fall up to 1934-5 with slight recovery in 1935-6.

Receipts from all sources for the group averaged between 88s. to 119s. per acre during the period reviewed.

Changes in Receipts, etc. (All Farms). The results of the larger group of unselected farms generally corroborated the results for the selected group of twelve farms covering the same period. Cattle receipts continue to fall from 1931 to 1934, and improved in the next two years. In dairy products, owing to the increasing number of dairy farms included in the group and in particular in the last two years, receipts by sales have increased gradually from 1931 to 1936. Receipts from sheep and wool fell to 1933 and then increased. Pigs declined until 1933 and then improved. Receipts from poultry and eggs increased to 1932, declined in the following year, then improved in the next two years and declined again in 1936. Total receipts dropped to 1932-3 then improved in the last three years.

On the expenses side the expenditure on labour fell to 1934 and then increased in the following two years. Cost of feeding-stuffs increased after 1932 but drastic cuts were made both in fertilisers and seeds up to 1933-4, and costs increased in the next two years. Expenses incurred on purchases of livestock declined up to 1933 and then increased in the next three years. Total expenditure fell to 1932-3 and then increased. Rent showed variable conditions, but as the farms were changing little importance can be attached to these results. Capital declined to 1933-4 and then increased.

The details are set out in Tables VI and VII.

Summary.

On the whole, agricultural produce as indicated by the Index numbers of the Ministry of Agriculture, realised better prices from 1932-3 up to 1935-6. The general index number for all agricultural produce increased gradually from 106 in 1932-3 to 117 in 1935-6 (110 and 123 if the wheat and cattle subsidies are taken into account). The results for all farms discussed (the group of selected farms, and all the farms for which records have been obtained) also show that on the whole there has been a gradual improvement in the farmers' financial position since 1932-3. But as over 90 per cent. of the receipts from these farms were derived from livestock and livestock products, the incomes on the farms would be almost entirely influenced by the prices of livestock and dairy products. Sheep have recovered from the low prices of 1931, and prices of fat sheep and store sheep on an average during

1935-6 were fifteen and twelve points respectively above pre-war values. Prices of sheep continued to improve in the autumn of 1936, but were still below those realised during 1929-30. Including the subsidy, fat cattle have made slightly over pre-war values, but these farms are more dependent on store cattle prices. While showing some improvement, prices of store cattle still remain low and this, combined with the very unsatisfactory price of butter, is having a very serious effect on the financial position of those farms where the raising of stores and the production of butter is the major enterprise. While prices of all classes of pigs had made some recovery in 1933-4 from the low prices of 1932-3, they declined again in the next two years. Prices of poultry have declined since 1929-30 and prices of eggs up to 1934-5, but with some improvement in 1935-6. Cheese and wool prices, which showed some recovery in 1935-6, were still below pre-war values. There has been an upward movement in the price of milk since 1931-2. The index number of prices for the crop years (September-August) 1929-30 to 1935-6 is given in the Appendix.

While these farms may not be fully representative of farming conditions in Wales, they do at any rate provide some evidence of the financial position for a fairly " normal " group of farms which are managed at normal standards in their areas and the land used for general or customary purposes. The results indicate some improvements in the financial condition, but full recovery to the conditions obtaining in 1929-30 requires a general improvement in the prices of livestock and livestock products. The indications are that the price of some farm products which constitute the major part of the receipts on these farms are improving, but they are still much below the prices realised during 1929-30, and while farm expenses remain at present levels, one cannot hope for any great improvement in the financial conditions on these farms during 1936-7.

APPENDIX.

Index Number for Crop Years.*
Base 1911-13 = 100.

Commodity.	*Crops Year (September to August).*						
	1929-30	1930-1	1931-2	1932-3	1933-4	1934-5	1935-6
General Agricultural Produce	139	125	114	106	113	115	117
General Agricultural Produce and Subsidies	—	—	—	110	117	121	123
Wheat	116	79	79	71	63	65	82
Wheat (inc Subsidy)	—	-	—	130	125	120	122
Barley	103	100	101	92	112	101	100
Oats	94	86	101	82	82	97	86
Potatoes	91	162	230	108	107	132	165
Hay	132	93	73	67	82	101	85
Fat Cattle	134	126	118	103	100	93	95
Fat Cattle (inc Subsidy)	-	—	—	—	—	107	113
Store Cattle	123	127	118	101	86	87	94
Dairy Cows	132	129	119	109	105	102	103
Fat Sheep	160	147	110	103	120	128	115
Store Sheep	155	146	92	80	95	108	112
Bacon Pigs	162	121	92	96	112	106	106
Pork Pigs	172	138	102	102	120	112	108
Store Pigs	126	136	110	109	142	132	126
Poultry	149	148	133	127	121	119	119
Eggs	148	125	110	107	103	105	115
Milk	164	159	139	147	161	171	177
Butter	140	114	106	94	91	86	95
Cheese	135	119	124	111	107	93	96
Wool	82	52	45	66	80	87	94
Feedingstuffs	110	82	94	88	84	92	87
Fertilisers	101	100	90	89	90	89	89

*From the Ministry of Agriculture and Fisheries Agricultural Market Reports.

MILK SELLING AND CATTLE RAISING IN WALES.

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Introduction.

The continued growth of interest of Welsh cattle producers in the milk market is causing serious concern in connection with the immediate and the more distant future of the cattle raising industry in the Principality. No exact measure of this interest was available until the inauguration of the Milk Marketing Scheme in 1933, although it was known to be considerable. According to statistics provided by the Milk Marketing Board the approximate number of gallons of milk sold under wholesale contracts in Wales in the years 1933-4 and 1934-5 and 1935-6 was 38,467,000; 52,017,000; and 55,386,000 in the respective years (*i.e.*, North Wales and South Wales regions taken together and Monmouthshire is not included in either

region). These figures show an increase of 44 per cent. in the quantity sold by wholesale from the first to the third year. Sales by producer-retailers are not included in this figure, and in the year 1933-4 these amounted to 14.1 per cent. of total sales in Wales. If it is assumed that the quantity of milk sold by producer-retailers has remained fairly stationary during this period it may be said that the total increase is about 37-38 per cent. which, by common acceptance, is regarded as an enormous increase in sales of milk over a period of three years. The increase in the volume of milk sold is largely due to the movement towards a secure market and away from markets offering little but continued disappointment with prices realised. Long established producers of milk for sale increased the size of herds and generally intensified methods leading to greater production. New producers of milk for sale also made their appearance; some of these had a strong background of experience in dairy farming in so far as they had been substantial producers of butter and cheese, particularly the former; others took to producing milk for sale without a background of experience in the serious production of cheese or butter for sale, and the change was a direct one from cattle raising to milk selling. Where well established producers of milk concentrated on increasing sales no fundamentally new problem was raised for the cattle industry. But with the conversion of butter and cheese making farms, and cattle raising farms, to the production of milk for sale quite new problems were raised in Welsh agriculture and no background of collected experience existed to assist in judging whether or not this change was and is wise.

But enough is known of the relationships of the industry of store cattle raising and the enterprises associated with it to realise that the change to milk production must have caused important and deep reactions both within the farms making the changes and in farms and markets outside of them. The questions raised now are important. Can farms rear calves and sell milk? If they cannot what is going to happen to the supply of heifers for dairy herds and to the supply of heifers and steers for producing prime beef? Moreover, what is eventually going to happen to the milk market if these new producers are to continue coming in to produce milk for sale? Examination of the way in which the milk market absorbed increased supplies in Wales shows that the proportion of the milk sold under wholesale contracts under the Milk Marketing Scheme put to manufacturing uses increased substantially during the last three years. In

1933-4 about 67 per cent. of this milk went to the liquid market and about 33 per cent. to the manufacturing market. In 1935-6 slightly over 50 per cent. of the milk entered the liquid market and slightly under 50 per cent. was manufactured into milk products. During this period the quantity manufactured more than doubled. It is quite clear, therefore, that much of the milk sold was put to almost the same use as it was on farms, the only difference being that the resulting product was made in factories and the usual by-products of butter-making and cheese-making were not available for feeding livestock on farms as was formerly the case. The net effect of pooling of receipts from milk has been to make producers selling to the liquid market help those selling to the manufacturing market, and the sellers to the liquid market feel aggrieved because they have to help in this way. But those who sell to the manufacturing market tend to look upon the pooling system as something which gives them the share they deserve of the milk market as a whole and therefore they tend to exploit it regardless of the consequences to themselves or others. This is a dangerous attitude and a menace to the cattle raising industry of Wales. At the same time the evolution of a clear cut policy of guidance concerning the possibility of selling milk alongside cattle raising is likely to provide the key to improvement of cattle stocks as well as providing means for helping distant producers of milk to participate in a relatively good market. If recent recommendations in connection with manufacturng milk are adopted it seems that the burden of the low price of this milk would be removed from the shoulders of producers for the liquid market and would be met out of State funds. (1). In the event of this occurring producers of milk for the liquid and the manufacturing market would secure greater identity of interests and less harm would result to liquid producers from sale of milk in distant manufacturing areas.

Cattle Supplies.

Some of the broad features of the cattle industry of Wales may be displayed by means of the annual official statistics of cattle on farms. (See Appendix A). During the present decade total numbers of cattle have declined from the highest point in 1932, yet numbers in the dairy and breeding herd stand at a higher level than ever and are estimated at over 400,000 head in 1936. (See Appendix B). This large potential capacity for further breeding is in itself a good thing, especially if the productivity of the land in Wales shows some improvement, and

recent research results indicate that this should be possible (2). Compared with 1930 total numbers of cattle increased by 9 per cent. in 1932 and remained at that level in 1933; since then a fall has occurred, but in 1936 numbers were still 7 per cent. above the level of 1930. During this period absolute numbers of all cattle (except bulls) increased. Bulls showed some decline in numbers mainly due to the operation of the Livestock Improvement (Licensing of Bulls) Act, 1931.

TABLE I.

Classes of Cattle (per 1,000 Total Cattle).
Wales and Monmouthshire.

Class.	*1930*	*1931*	*1932*	*1933*	*1934*	*1935*	*1936*
Breeding Cattle:							
Cows in Milk .	340	329	322	323	327	332	331
Cows in Calf .	41	44	46	46	44	51	51
Heifers in Calf .	49	48	42	44	43	51	50
Bulls .	14	15	11	14	11	12	12
Total Breeding Cattle	444	436	421	427	428	446	444
Other Cattle:							
Under 1 year	241	252	246	235	229	222	239
1 year and under 2	217	222	231	235	235	230	220
2 years and over	98	90	99	103	108	102	97
Total Other Cattle	556	564	576	573	572	554	556
Grand Total	1,000	1,000	1,000	1,000	1,000	1,000	1,000

Table I shows the number of cattle by classes per 1,000 head of total cattle. This shows that the dairy herd was relatively as important in 1930 as it was in 1936, and numbers of cows in milk were relatively higher at that time than they have been since. Taking the dairy herd as the sum of the numbers of cows in milk and cows in calf relative decline in numbers occurred in 1932 and since then the opposite became manifest until the highest figure for the present decade was attained in 1935. Heifers in calf also showed relative decline in numbers during the middle three years of the present decade, but a sharp increase occurred in 1935 During the same period bulls declined by about two per 1,000 in total cattle. Two year old cattle were as important in 1930 as in 1936, and the period 1931-4 showed a continued increase in proportions per 1,000 total cattle. Exactly the same tendency characterised numbers of yearling cattle, and the class under one year old showed increases in relative numbers from 1930 to 1931, a continuous decline from 1931 to 1935, but a sharp recovery in 1936.

If it is assumed, as in Table II, that cows in milk and in calf constitute the cattle already in the dairy herds of Wales, then the relationship of numbers of all other classes to dairy herds kept is more clearly established. Heifers in calf were fairly high

TABLE II.

Classes of Cattle (per 1,000 cows in milk/or in calf). Wales and Monmouthshire.

Class.	*1930*	*1931*	*1932*	*1933*	*1934*	*1935*	*1936*
Cows in Milk / Cows in Calf	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Heifers in Calf	126	128	116	122	116	131	130
Bulls	38	39	37	38	38	30	30
Other Cattle:							
Under 1 year ...	631	679	673	637	614	580	625
1 year and under 2	569	598	631	636	630	601	576
2 years and over ...	257	211	271	280	291	268	255

per 1,000 cows in the herd in the years 1930 and 1931, and on the whole much lower in the next three years, but numbers recovered sharply in 1935 and continued almost at that level in 1936. Measured in the same way the number of bulls showed a tendency to relative decline from the beginning of the present decade and the heaviest decline occurred in 1935. Though relative numbers of cattle over two years old decreased in the second year of the present decade the general tendency was for them to increase in numbers in relation to the dairy herd to 1934 but since then continuous and substantial declines have occurred.

From 1931 onwards there seems to have been some loss of confidence in the milk market and consequently less use of heifers for breeding. Then as the numbers of young cattle reared were tending to increase, a somewhat higher proportion and total were directed to the beef store market. As this market weakened in 1933 and 1934 there was difficulty in selling. Some farmers who could afford it, or who hoped for better times, held cattle on farms longer than usual, hence some accumulation on farms. The effect of the lower transfer of heifers and of any tendency to hold up stores on farms was liquidated in the autumn of 1934 and the spring of 1935 and the relations between the heifers for the cow market and stores for the beef market became more normal in 1935 when the number of heifers increased.

Numbers of cattle one year and under two years old measured in the same way increased to 1933 and then declined and the class under one year old increased up to 1931 and then declined continuously to 1935 and increased again in 1936. The

number of cattle under one year old is always much lower than the combined total of the cows in milk and in calf. But the figures seem to be closely related. Even so it is not possible to estimate the number of calves slaughtered with any degree of accuracy. There are three variables concerned—birth rate, death rate and slaughter rate. All these can vary enormously but it can be said that fewer calves survived per 100 cows in milk and in calf in the years 1930-31 to 1934-5 than at any other time in the present decade. And, in this respect it is probable that the combined effect of the factors concerned exercised their maximum influence in the year 1934-5. The tendency to increase in the number of two-year old stores in 1933 and 1934 owing to the difficulty of satisfactory marketing tended to discourage rearing of yearlings at this time.

Table III indicates the number of calves per 100 cows in milk and in calf since 1930, assuming that the calves appearing in the class under one year old are born from the same number of cows as is recorded in the same year. Despite the fact that there is a

TABLE III.

Relationship of Numbers of Cows to Numbers of Cattle reared aged under one year.

	Cows in Milk or in Calf.		*Cattle under 1 year old.*		
Year.	*Number.*	*Per cent. of 1930.*	*Number.*	*Per cent. of 1930.*	*Number per 100 cows in milk or in calf.*
1930	299,532	100	189,039	100	63
1931	305,303	102	207,219	110	68
1932	314,078	105	211,442	112	67
1933	315,916	105	201,087	106	63
1934	317,226	106	194,636	103	61
1935	318,462	106	184,747	98	58
1936	321,859	107	201,158	106	62

little error in this assumption it is of small account when the same process is repeated for each succeeding year. The relationship established is a close one and it shows that the number of calves reared per 100 cows in milk and in calf rose in 1931 then declined continuously to 1935 and increased again in 1936. The practical result has been that calves per 100 cows increased by four in the last year but they were still six below the highest number of the present decade.

The cattle recorded as under one year shift to the class one year and under two years old by the following year and examination of Table IV shows the number per 100 cows in milk and in calf that shifted. It appears from the Table that few of the cattle recorded as calves in one year fail to get to the class immediately above in the following year and the greatest difference between the comparative figures in any two years is three, which occurred when the " under one year olds " of 1931 became the " one and under two year olds " of 1932. Imports of store cattle help to increase the numbers recorded in this class but it is assumed that this influence is constant during the period 1930 to 1936. And even if imports account for a number of cattle in this class it seems certain that their influence is small because the relationship between the number of calves in one year and

TABLE IV.

Relationship of Numbers of Dairy Cows to Numbers of Cattle reared aged one year but under two years old.

Wales and Monmouthshire.

Year	*Cows in Milk or in Calf*		Year	*Cattle 1 but under 2 years old*		
	Number.	*Per cent. of 1930.*		*Number*	*Per cent of 1931*	*Number per 100 Cows in Milk or in Calf.*
1930	299,532	100	1931	182,559	100	61
1931	305,303	102	1932	199,265	109	65
1932	314,078	105	1933	200,765	110	64
1933	315,916	105	1934	199,868	109	63
1934	317,226	106	1935	191,487	103	60
1935	318,462	106	1936	185 340	102	58

yearlings in the next year is so remarkably close. So it would appear that there is relatively little disappearance of cattle recorded as under one year before they reach the class one year and under two years.

Increases or decreases of relative numbers of cattle under two years old have occurred quite regularly during the period in response to increases or decreases in relative numbers of cattle under one in the previous year (Table IV.) It may be said then that numbers of cattle in the class one and under two years will increase in 1937 if these normal relationships still hold. The number is estimated at about 195,000.

Comparatively few of the cattle one year and under two years reach the class two years and over in the following year and the disappearance in sales as stores or fat during this period

in the life of cattle is heavy. Estimated disappearances after deducting estimated deaths for the years stated are given below :—

Year.	*Estimated Number (excluding deaths).*
1931-2	166,000
1932-3	189,000
1933-4	189,000
1934-5	199,000
1935-6	180,000

No firm estimate can be given for the year 1936-7. But it does appear that the number will be considerably lower than that for 1935-6 because numbers of cattle coming into the class from which the great bulk of the sales of store cattle are made were considerably lower in 1936 than in 1935, but a recovery may occur in numbers in 1937-8 because numbers of cattle going into the class from which sales are made are likely to be much greater. It appears therefore that supplies of home reared store cattle will show some increase in Wales in the autumn of 1937 and spring of 1938 subject, of course, to normal conditions in markets, external supplies and breeding policies.

Cattle other than cows that are estimated to disappear from herds for reasons apart from death at any age over one year old are used for these purposes :—

(1) Some are heifers used for maintenance of herds outside Wales.

(2) Some are sold beyond the boundaries of Wales as stores either for feeding or for rearing.

(3) Some are fattened in Wales and subsequently slaughtered in or outside of Wales.

All heifers reared must come at some time from the classes of cattle over one year old. The relationship between cows already in the dairy herd and the number of heifers in calf is fairly constant and the latter amounted to about 11-13 per cent. of the former in the period 1930 to 1936. But more heifers than this are required to maintain herds in Wales and it is estimated that the extra heifers required, which are not in calf when the records are made, amount to about 11½ per cent. of the cows in milk and in calf. It follows therefore that the bulk of cattle are sold as stores beyond Wales but a large number are fattened in Wales. Some indication of the numbers fattened may be gained from numbers of animals certified for subsidy in Wales in 1934-5 and 1935-6. The figures were 84,000 and 86,000 respectively.

The interest of the raisers of cattle in Wales are therefore centred mainly in store cattle production but also to an increasing extent in the production of fat cattle.

The extent to which stocks of cattle on farms in Wales are devoted to dairy and beef purposes is shown in Table V.

TABLE V.

Dairy and Beef Herds in Wales in December, 1936.

	Numbers.			*Proportions.*	
	Dairy (000)	*Beef* (000)	*Total.* (000)	*Dairy* %	*Beef* %
Cows and Heifers in Milk	152	80	232	65.5	34.5
Cows in Calf .	57	41	98	58.0	42.0
Heifers in Calf .	34	20	54	63.0	37.0
Bulls used for Service	6	4	10	60.0	40.0
Bulls and calves reared for Service	3	3	6	50.0	50.0
Other Cattle:					
2 years and over	16	52	68	23.6	76.4
1 to 2 years .	65	99	164	39.6	60.4
Under 1 year for rearing	91	100	191	47.6	52.4
Calves for Slaughter	2	2	4	50.0	50.0
Total .	426	401	827	51.5	48.5

Nearly two-thirds of the cows in milk are in dairy herds and a little over one-third are in beef herds; 60 per cent. of the cows and heifers in calf are in the former type of herds and 40 per cent. are in the latter. This shows that the proportion of cows and heifers in milk or in calf which are used for beef purposes is appreciable. Bulls used for service are distributed between the dairy and beef uses in the ratio of six to four and the numbers of bull calves being reared for service are equally distributed between the two uses.

Except for calves slaughtered, which are equally divided between dairy and beef herds, more of the classes designated "other cattle" are intended for beef than for dairy uses and the proportion to be so used increases with the increase in age of animals.

Turnover of Cattle.

Such are the general conditions on all Welsh farms when considered as one unit.

Some information on conditions existing on farms of different types is provided by farm accounts.[1] The different types have been selected according to natural and economic conditions which

[1] Data below abstracted from statement for 1935-6 provided by Mr. J. Pryse Howell, M.Sc., University College, Aberystwyth.

exist in Wales and will be fairly well recognised by those who are conversant with its agriculture. Proportions of total receipts which are obtained by sales of cattle mark some of the differences as regards economic dependence on the cattle industry :—

Group.	*No. of Farms.*	*Cattle Sales as per cent. of Total Receipts.*
1. Cattle and Sheep (Poor Land) .	11	30
2. Cattle and Sheep (Better Land)	13	38
3. Mixed Farms . .	12	15
4. Dairy Farms (Less than 40 per cent. receipts from milk) . .	8	26
5. Dairy Farms (40-50 per cent. receipts from milk) . .	13	19
6. Dairy Farms (over 50 per cent. receipts from milk)	11	9
Total and Average .	68	22

Differences in the character of the cattle enterprise from one type to another are clearly indicated by figures which show the relation of numbers of other cattle normally on the farms to the numbers of cows normally kept, and by the numbers of cattle of different types and ages bought and sold.

TABLE VI.

Stocking of Farms (Cattle per 100 cows in Herd). 1935-36.

Particulars.	*Groups.* 1	2	3	4	5	6	*All Groups*
Heifers in Calf	22	12	11	14	18	9	15
Bulls .	5	5	4	6	3	5	5
Calves under 3 months	35	46	25	14	16	9	21
Under 1 and over 3 months	78	89	52	22	32	12	41
1 year and under 2.	77	118	74	44	38	11	53
2 years and over .	28	57	27	20	19	6	24
Total . . .	245	327	196	120	126	52	159

It has been shown above that over the whole of Welsh farms the recent ratios of other cattle to cows have varied between 178 and 161 to 100; and in 1935-6 the ratio of other cattle to cows was about 161. The figures above thus correspond fairly closely with the general averages.

But as may be seen the average is made up of farms at the upper end of the grouping, especially in Group 1, which buy calves for rearing, and farms at the lower end of the grouping which sell

very considerable numbers of calves. Over the whole of Welsh farms there is a considerable net sale of calves for slaughter, either at a few days old or after fattening for veal, and apparently all types tend to sell some calves.

TABLE VII.

Net Sales of Cattle. 1935-6.

Particulars.	*Stock Carried.*	*Purchases.*	*Sales.*	*Net Sales.*
Cows	1,038	169	280	111
Heifers in Calf	152	18	22	4
Bulls	47	15	54	39
Calves under 3 months	222	213	522	309
3 months and under 1 year	430	23	25	2
1 year and under 2	552	441	395	-- 46
2 years and over	245	34	380	346
Total	2,686	913	1,678	765

The "poor land" farms rear a considerable number of cattle for sale, mostly of the age of twenty to twenty-four months, and the remainder are sold mainly as stores from two years upwards usually up to thirty months. These farmers also sell an appreciable number of cows for dairy herds as well as some stock bulls; many more cattle under one year old are purchased than are sold but more particularly young calves.

The "better land" farms buy few and sell many cows and bulls for breeding, but they buy many more cattle in proportion to foundation herds and sell them mainly under two years of age but an appreciable number are over two years. Almost half of these cattle are sold fat and earn the cattle subsidy. Young calves are purchased but not nearly so many as store cattle of about fifteen months of age.

The group "mixed farms" is more interested in cattle to raise beef and to produce milk than in rearing. Cows culled from herds are sold as well as appreciable numbers of calves and store and fat cattle, but purchases of stores much exceed sales.

The groups of farms devoted to "dairying" sell large numbers of cows which are largely weeded out of herds. Sales of calves are heavy and about five times the numbers purchased. Yearlings are bought in particularly large numbers and sold in appreciable numbers. Older cattle are mainly sold fat and about a half of the cattle over one year old are sold in this condition and get the fat cattle subsidy.

Farms in groups 1 and 2 supply cows and bulls for foundation stock in dairy herds but the strong interest of the second group in beef is bound to limit their capacity to continue to do this because half of the cattle sold over a year old are purchased. Group 3 rely largely on purchased supplies of cattle at low ages and could supply but little stock to others. All the farms in the dairy groups, except those in group 4, purchased cows and bulls for foundation purposes for sales largely consisted of animals having passed their useful milking or breeding lives. Group 4, however, sell some prime dairy cows but their capacity for doing so is limited according to the sizes of milk selling enterprises.

Turnover of Cattle on milk selling Farms.

Information relating to milking herds spread all over Wales and Monmouthshire is instructive on certain aspects of the matters raised here.[2]

TABLE VIII.

Turnover of Cows and Calves.
(Per 100 cows in Herd)

Particulars.	Area 1.		Area 2.	
	1934-5.	*1935-6.*	*1934-5.*	*1935-6.*
Number of Farms	34	29	32	30
Size of Herd ...	35	30	21	25
Transfers :				
In ..	31	47	31	28
Out ...	32	48	27	30
Cows Homebred	17	42	57	58
Calves :				
Born ...	62	69	75	84
Sold .	37	32	42	49
Retained	18	27	31	31
Died ..	7	10	2	4

It will be seen that from a little under to a little over one-half of the cows in herds have been home bred. But of the transfers into herds by far the greatest number are purchased, the heaviest purchases being recorded for Area 1. In both areas, however, the numbers transferred from herds are mainly on account of sales, deaths being 2 per cent. and transfer to other purposes other than milking only 3 per cent. of herds.

[2] Data below abstracted from material provided by Messrs. H. E. Evans, B.Sc., and J. D. Griffiths, N.D.D., Department of Agricultural Economics, University College, Aberystwyth.

The numbers of calves handled in dairy herds are closely associated with the method of maintaining herds, whether by rearing or purchase. In the groups dealt with above, that showing the highest proportion of home-bred cows shows also the higher ratio of calves to cows. But when there is frequent inward transfer, and a considerable proportion of cows are purchased the number of calves born will normally be considerably lower than the number of cows in herd. But in these two groups of herds only 34 and 39 per cent. of the calves born are retained for rearing. It will be noticed, that the numbers of calves retained in Area 1 are lower than the numbers of cows transferred into the herds, but that in Area 2 calves retained and cows transferred into the herds are equal in number. But allowing for deaths and some rearing of bulls and steers, neither of the groups of herds was rearing enough calves for maintenance, and Area 1 must purchase at least half of its maintenance cows.

Effects of changes from Butter-making to Milk-selling.

It is relatively easy to obtain material showing conditions on different types of farms which are fairly static, but hitherto it has not been possible to obtain any close measurement of the effects of changes from a combined system of making butter and rearing calves to a system of selling milk. Hence a survey of a number of farms which had recently made this change was conducted last year. In the area concerned all producers sell milk for the manufacturing markets; some of them buy separated milk returned from the factories but others do not. The relevant facts are displayed in Table IX.

TABLE IX.

Comparison of effect on calf rearing of conversion to milk-selling.

Particulars	*Group 1.**		*Group 2.†*	
Number of Farms	13		23	
Size of Herd per Farm:				
(*a*) Before milk-selling	8.6		11.6	
(*b*) After milk-selling	11.0		11.5	
Calves reared per Farm:				
(*a*) Before milk-selling	10.2		9.9	
(*b*) After milk-selling	5.7		8.9	
Calves reared per cow in Herd:				
(*a*) Before milk-selling	1.2		0.8	
(*b*) After milk-selling	0.5		0.6	
Butter made per week, per cow (lb.)	*Winter*	*Summer*	*Winter*	*Summer*
(*a*) Before milk-selling	1.4	3.8	1.7	4.4
(*b*) After milk-selling	none	none	none	none

* Group 1. No skim milk returned to farm.
† Group 2. Skim milk returned to farm.

When the herd enterprise is changed from making butter and rearing to that of selling milk much of the character and amount of effects may depend on whether any equivalent to a supply of the skimmed milk of the farm is available and the only near equivalent in the judgment of many farmers is the skimmed milk from the factories. Hence further analysis is necessary according to the breaking or continuation of the supply of skimmed milk. But it should be said that farmers who make this change, and perhaps especially those with considerable proportions of second-class land, not infrequently attempt to modify its possible effects by keeping a portion of each daily supply of whole milk. Their contracts for sale frequently if not universally require the daily sale of the whole production of the herd, but it appears that this condition is interpreted with considerable liberality by both parties. Sometimes the requirement is that of the delivery of the production of a specified number of cows.

Farms without Skimmed Milk.

These farms show an average increase in dairy herd of 28 per cent. and this change has been made relatively rapidly, for few of the farms in this group had been selling milk for more than two years and most of them had been doing so for not more than one year. The number of calves reared on farms declined by about 44 per cent. in the course of the change from butter-making to milk-selling while the number of calves reared per cow declined by 58 per cent. That is to say that out of every 100 calves reared on this group of farms before conversion to milk-selling only fifty-six are now reared, and instead of rearing 120 calves per 100 cows only fifty are now reared. It must not be inferred, however, that every farm shows results similar to those of the whole group, for naturally some reared less calves than the average figure shown while others reared more.

Some of the reasons for these effects are fairly simple. Prices of store cattle have been ruinous and with improvement in transport facilities and growth of possibilities of exploitation of the milk market milk-selling was adopted. This led to the selling of as much milk as possible according to the terms of contracts made with buyers. There remained little fresh milk on farms to feed calves in the first weeks of their lives and no skim milk to mix with whole milk to feed them for a time prior to feeding on skim milk alone. Under such circumstances new methods of calf feeding and rearing had to be discovered and applied or less calves had to be reared and as seems to be generally the case the latter course was adopted. The methods of calf rearing

adopted and the amount of milk fed per calf prior to milk-selling showed little variation from farm to farm and calves were allowed to suckle their dams for a few days and subsequently bucket fed on whole milk for about a month and from 1½ to 2 gallons were fed per calf, given in two feeds, night and morning. Separated milk was then introduced and the quantity fed increased and the amount of whole milk decreased as the calf became older. Some differences in practices occurred at this point and in some cases the transition to a complete liquid diet of separated milk was made rapidly and calf meals of various kinds used as supplementary feed. In other cases a little whole milk was mixed with the separated milk until calves became about six months old. The farmers adopting the latter method held the view that very little whole milk in the diet made an enormous difference in the constitution of the calves reared and added that this was particularly noticeable when machine skimmed milk rather than farm skimmed milk was used. On practically all the farms in the group calves reared were subsequently sold in store cattle markets.

The calves now reared are raised in two ways. On those farms which concentrate on as high sale of milk as possible the calves, after a few days suckling, are fed on purchased calf foods which are mixed with water Some of the farmers, however, are entering milk-selling more cautiously and still retain some cows for calf rearing and feed calf meal and water with whole milk. That is to say they continue as previously but without skim milk because no butter is being made and therefore there is no skim milk available.[5] The seriousness of producers in milk production may be gauged from the proportion getting the accredited milk bonus and the buyers' bonus paid on the basis of quality of production. Five producers get the former and seventeen the latter payment, which varies from ¼d. to 1d. per gallon. But so far as producers' views could be ascertained it appears that practically all of them intend to continue in the new line of production. Moreover, they value the method of payment affording bonus according to quality of product and they are beginning to ask questions how this quality is determined and who does the determination and reporting on samples. They also value the services of free churns and strainers. The fact that their milk production enterprises would have to be self-supporting after present non-dairy stock has been sold is very

[5] Butter for home consumption is often, but not always, bought from buyers of the milk.

imperfectly appreciated. Farm women, especially, welcome the absence of butter-making and absence or reduction of calf feeding in their normal farm work and therefore in most cases they do not wish to have skim milk returned to the farms. Only a few farmers claim that they can rear as good calves without skim milk as with it. But the fight for existence had gone so much against them when they relied for revenue on cattle and butter markets that they acquiesced in the strong feeling against butter-making and calf rearing expressed by their women folk and went to milk-selling without properly understanding the factors involved.

Farms Receiving Skimmed Milk.

Group 2 contains a lower number of farms than Group 1, but there is no reason to suppose that the results for this group are any less representative on that account. As compared with the pre-milk-selling period the increase in the average numbers of cows in the herds is 25 per cent., the decrease in numbers of calves reared per farm is 11 per cent., and the decrease in the number of calves reared per cow is 25 per cent. That is to say, there has been a decrease in numbers of calves reared both relatively and absolutely since the conversion from butter-making to milk-selling. It follows therefore, that this change has involved a decrease in numbers of calves reared irrespective of the fact that separated milk is returned to farms for use to feed livestock and particularly to rear calves. During certain periods of the year, notably on hot sultry days, the skim milk is very sour and difficulty is experienced in getting calves to drink it. On this account many farmers feed the milk to pigs, others, however, persevere and coax calves into drinking such milk and get quite good results from its use. Most producers agree that this skim milk is well worth the money paid for it, which was ½d. per gallon at the time this survey was made. The method of calf rearing adopted by this group prior to milk-selling was almost identical with that adopted under similar circumstances by Group 1. But there was this difference; because more attention was given by this group to butter-making calves were allowed less time for suckling dams and were weaned at a lower age and generally less whole milk was fed prior to their being fed on skim milk supplemented by calf meals. Water did not wholly replace skim milk in the diet until calves were about five-six months old.

Some of the producers in the group still adopt this method of calf rearing alongside milk-selling and keep a few extra cows for the purpose of providing the necessary quantity of whole

milk. The calves reared are mainly sold in the cattle market as normal or forward stores and some are fattened for slaughter.

This group sells milk to a factory paying no buyers' bonus according to quality, but the proportion of accredited producers is higher than in Group 1, being nine out of twenty-three producers. Producers provide their own churns and strainers, as a rule they buy butter from the buyer of their milk. Recently, however, they have benefitted a little in respect of the transport charges as compared with Group 1. Apart from these small differences the only outstanding difference in the two groups at present is the fact that one of them buys skim milk for feeding livestock from the buyer of their milk and the other does not. But the change made by Group 1 was far more revolutionary than that made by Group 2, because the latter had previously raised the relative importance of butter-making in the combination of butter and cattle, while Group 1 had continued to attach relatively high importance to cattle. Time alone will answer the question as to the number which will survive the bold decision to make drastic change.

But the study shows clearly that Group 2 has been able to maintain the structure of its farming during a period of change to a greater degree than Group 1. A problem of some importance is raised as to the possibility of providing suitable facilities for farmers in areas where manufacturing milk can be produced to take advantage of the relatively good price for milk in the milk market and at the same time retain the essential structure of their farming.

Conclusions.

The general statistics show that maintenance of the cattle supply may be consistent with an increase in the dairy herd (cows and heifers in milk and cows in calf) of the order of the increases which have occurred. They also indicate that maintenance of the cattle supply may be consistent with an increase in the sale of milk. But there have been some special conditions affecting the production and flow of supplies of cattle since 1931. There appears to have been a general tendency towards increase in the supply—due either to increasing capacity of production on pastures, or to cheap supplies of feeds, or possibly to both. Possibly changes in the sheep flock have set some pastures free for cattle. But, given no shortage in capacity for production, and no drastic change in methods, an increase in the foundation herd might bring increases in other cattle.

The figures dealt with show that the milking herds (Table VIII) are not maintained by the calves retained from those which they produce. Hence it is necessary that breeding shall be maintained outside these herds. Then figures dealt with (Table IX) show that herds recently converted from stock-raising to milk-selling on land tending to second-class quality will continue to produce some stock for sale, but while these figures are not conclusive they provide very strong indication of considerable reductions in supplies of cattle from such converted herds even though arrangements are made for returning separated milk to farms. However, farms of this type will continue to produce surplus of cattle; they need to maintain as nearly as possible the pre-change numbers of bovine stock to ensure the full utilisation of their pastures and hay and unless they do so they are likely to suffer.

The evidence so far dealt with is supported by that of farm accounts (Tables VI and VII) which show two fairly clearly defined sets of farms which are concerned with bovine production —those with a heavy dependence on cattle, and those with a heavy dependence on milk, with an intermediate group having fairly heavy dependence on milk, and considerable dependence (26 per cent. of total receipts) on cattle.

If it must be accepted as axiomatic that the farmers who turn to milk-selling will rear and sell smaller numbers of cattle, then the maintenance of the supply of cattle, especially for the beef market, turns upon the capacity of the existing stock-raising farms (and those which continue in the future) to increase their production of cattle. So far as it goes the available evidence indicates that changes towards milk-selling of the order of those which have occurred, and consequent reductions in supplies of cattle, may be balanced by increase in production of cattle on other farms. Danger to the supplies of cattle arises rather from such low prices as ruled in the markets during 1934 and 1935. Even though the prices have since risen they have not yet reached the level at which the maximum supply of cattle on contemporary producing capacity is likely to be reached. With rising prices of requirements a further rise in prices of store cattle is likely to be necessary to bring forward the full supply.

The question of quality of stock is more intricate, but here again, especially as regards the farms on which most of the cattle reared are also bred, much depends upon prices. They can and will produce cattle of good beef type and quality when prices are equivalent to those for heifers of dairy type. But

where, as is quite generally the case, the heavier stock-raising farms must buy calves in order to maintain their output, then the quality of their supplies will depend upon the quality of the calves that are sold from the milking herds. The rearing farms of West and Mid-Wales get many calves from the more concentrated milk districts of South Wales, while those of North Wales and some of the Northern parts of Mid-Wales get considerable numbers of calves from Cheshire. Although there is considerable

APPENDIX A.

Cattle in Wales and Monmouth.

Year.	*Cows and Heifers in Milk and in Calf.*	*Heifers in Calf.*	*Bulls being used for Service.*	*Other Cattle*			*Total.*
				Under one year.	*1—2 years.*	*Two years and above.*	
1928	302,921	30,000	11,253	195,390	195,220	83,273	818,057
1929	296,911	33,787	10,848	183,572	185,628	82,950	793,696
1930	299,532	37,601	11,395	189,039	170,315	76,868	784,750
1931	305,303	39,118	11,999	207,219	182,559	73,689	819,887
1932	314,078	36,368	11,707	211,442	199,265	84,982	857,842
1933	315,916	38,593	12,112	201,087	200,765	88,384	856,857
1934	317,226	36,780	12,093	194,636	199,868	92,417	853,020
1935	318,462	41,753	9,645	184,747	191,187	85,484	831,578
1936	321,859	41,881	9,500	201,158	185,340	82,101	841,839

selection and many calves of poor breeding or constitution get slaughtered at quite an early age, too many of mediocre breeding and constitution go to the rearing farms to be sent forward at a later date to the milk producers and fatteners.

APPENDIX B.

Reconstitution of the Cattle Population of Wales and Monmouth.

Year.	Cows in Milk and in Calf.	Heifers in Calf (in June).	Maintenance Heifers not in Calf in June.*	Total Heifers.*	Bulls required.	Total Dairy and Breeding Herd.*	Cattle under one year old.	Cattle 1—2 years old.	Cattle 2 + (excl. maintenance Heifers and Bulls)*	Total (equivalent to all recorded Cattle).
1928	302,921	30,000	31,836	61,836	11,253	379,010	195,390	195,220	48,437	818,057
1929	296,911	33,787	34,144	67,931	10,848	375,690	183,572	185,628	48,806	793,696
1930	299,532	37,601	31,446	72,047	11,395	382,974	189,039	170,315	42,422	784,750
1931	305,303	39,118	35,110	74,228	11,999	391,530	207,219	182,559	38,579	819,887
1932	314,078	36,368	36,119	72,487	11,707	398,272	211,442	199,265	48,863	857,842
1933	315,916	38,593	36,330	74,923	12,112	402,951	201,087	200,765	52,054	856,857
1934	317,226	36,780	36,481	73,261	12,093	402,580	194,636	199,868	55,936	853,020
1935	318,462	41,753	36,623	78,376	9,615	406,183	184,747	191,187	48,861	831,578
1936	321,859	41,881	37,014	78,895	9,500*	410,254	201,158	185,310	45,087	841,839

* Estimated.

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RECENT COSTS OF MILK PRODUCTION IN WALES.

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As a scheme for ascertainment of costs of producing milk has been in operation since November, 1934, a preliminary statement of some of the chief results may be of interest to farmers. The time has been divided into two periods or "years," the earlier consisting of eleven months ending on the 28th September, 1935, and the later ending on the 26th September, 1936. In view of the fact that the first period did not cover a full twelve months only a limited analysis of results is published, but fuller results for the year 1935-6 may be presented.

Results in 1934-5.

Sixty-six farmers co-operated during the first period. Their herds contained 1,958 cows of which, generally, 1,596 were in milk, forty-eight suckling and 314 were dry. The milk produced amounted to 1,155,668 gallons, equal to 590 gallons per cow in herd and 702 gallons apiece for cows in milk. Allowing for the fact that the period was only eleven months, these yields are equal to, say, 640-650 and 760-770 respectively in a full year. The size of herds varied between twelve and eighty and averaged 29-30 cows each, so that on the whole these herds are larger than the general run of those found in Wales. Net costs ranged from £10 0s. 0d. to £32 15s. 0d. per cow and 5.34d. to 15.21d. per gallon.

Basis of Costs.

Home Grown Foods. Values of home-grown foods in milk production, here taken as costs, were assessed on their values *on the farms* as reported monthly in the *Journal of the Ministry of Agriculture.* These values are based on the average market prices of a representative group of foodstuffs commonly used in

making up rations so values of home-grown foods are fixed according to their starch equivalent and protein content and the comparative cost of these contents as they might be purchased in the form of the representative group of feeds. The figures used for home-grown foods therefore do not necessarily represent either cost or market price. The average unit costs were as follows :—

	Per ton. £ s. d.
Hay	2 14 10
Straw	1 10 11
Roots and other Green Foods	0 12 6
Home Grown Corn	4 11 1

TABLE I.

Cost of Milk Production (66 herds).
(1st November, 1934—30th September, 1935).

	Cost per Cow.	*Cost per gallon.*	*Per cent. to Total.*
(1) *Foods.*	£ s. d.	*Pence.*	%
Purchased	6 16 1	2.76	27.83
Home Grown	4 16 1	1.96	19.65
Grazing	2 16 5	1.15	11.53
Total	14 8 7	5.87	59.01
(2) *Labour.*			
Employees	3 4 6	1.31	13.19
Family	2 1 11	0.85	8.57
Total	5 6 5	2.16	21.76
(3) *Miscellaneous.*	2 10 4	1.02	10.30
(4) *Depreciation.*	2 3 8	0.88	8.93
Gross Farm Costs	24 9 0	9.93	100.0
(5) *Credits.*			
Calves	1 0 0	0.41	8.99
Manurial Residues	1 2 0	0.45	
Net Farm Costs	22 7 0	9.07	91.41

Average number of Cows in Herd = 29.7.
Yield per Cow in Herd (gallons) = 590.

All *purchased goods*, feed, etc., were charged at the price paid plus carriage (if any) to the farm. The average price for cakes and meals was £7 1s. 1d. per ton. In arriving at the cost of *grazing*, detailed statements were obtained each month of the work done on grassland, manures applied and livestock carried. From this data it was possible to value the labour and fertilisers, etc., applied to estimate total cost and apportion due shares to the dairy cows and other stock. Charges for aftermath of the

hay crop were assessed at one-third of the full grazing costs. *Labour* includes all production labour costs (feeding, milking and general work on the dairy cows) Family labour was allowed the rate of wages paid for hired workers of a similar class, except that any work of a manual nature done by the farmer was charged at the highest rate paid on the farm. *Depreciation on the herds* was determined by taking the valuation of the herd at the beginning of the year plus the price of the cows bought and the value of heifers transferred into the herds; deducting the sales of cows plus the valuation of the herd at the end of the year: the difference being the amount of depreciation. *Miscellaneous items.* Rental charges for cowshed and dairy buildings were arrived at by consultation with the farmer. Separate records were kept for the purpose of arriving at cost of upkeep of bulls and credits for service fees were deducted from gross costs. Veterinary and medicines bills includes all expenditures of this nature incurred in connection with the dairy herd. Milking machine expenses include depreciation, cost of running and keeping in repair. Dairy equipment includes cost of upkeep and depreciation. General dairy expenses includes such items as brooms, brushes, soap, soda, milk recording fees, milk tests, etc. General farm expenses represents that part of the overhead charges of a farm which, as far as can be reasonably calculated, is chargeable to dairy cows.

Credits. The values of all calves sold and retained were credited to the dairy herd. Those retained were valued by the farmer according to market value (less cost of marketing) at four days old. Manurial residues were valued at one-half the theoretical values as set out by the standard tables.

Results in 1935-6.

For the fifty-two weeks (28th September, 1935, to 26th September, 1936), returns were obtained from fifty-nine farms. These carried 1,596 cows which produced 1,109,172 gallons of milk. The total capital invested for dairy purposes was £43,196 15s. 8d., distributed as follows :—

Capital Invested.

	Per Farm.	*Per Cow in Herd*
Dairy Cows .	497	18 8 0
Other Dairy Cattle .	157	5 16 0
Dairy Equipment	78	2 18 0
Total . .	732	27 2 0

Summer and winter costs are presented for periods of twenty-six weeks each, with costs over the whole year.

The proportion of dry cows is higher in winter than in the summer, but the proportion of cows suckling remains the same for both periods. On an average about 17 per cent. of the herds are dry during the whole period and slightly less than 3 per cent. are suckling. The average dry period was about nine weeks.

Total Number of Cows.

	Winter	*% to Total*	*Summer*	*% to Total.*	*Whole Period*	*% to Total.*
	No.	%	*No*	%	*No.*	%
Cows in Milk.	1,258	78.0	1,310	83.0	1,284	80.4
Cows Suckling.. ..	43	2.7	43	2.7	43	2.7
Cows Dry	312	19.3	226	14.3	269	16.9
Total	1,613	100.0	1,579	100.0	1,596	100.0

About 45 per cent of the total output of milk was produced in the winter and about 55 per cent. in the summer. The daily yield per cow in herd indicates that summer production was about three pints higher than in winter, but some of this is due to the slightly higher proportion of cows milking in summer. While these figures indicate average conditions it must be borne in mind that within this group of fifty-nine herds there are cases where the difference between summer and winter production is considerable.

Production of Milk.

	% to Total. %	*Yield per cow in Herd. Gallons.*	*Yield per cow in Milk. Gallons.*	*Daily yield per cow in Herd. Gallons.*	*Daily yield per cow in Milk. Gallons.*
Winter	45.2	286	367	1.57	2.01
Summer	54.8	355	426	1.94	2.33
Total ...	100.0	639	791	1.74	2.17

Nearly 84 per cent. of the milk produced during the whole period was disposed of to the wholesale market. Sales by semi-wholesale are insignificant but retail milk accounted for nearly 8 per cent.[1]

Milk sold and given as a perquisite to employees, and used in farmhouse amounted to nearly 2 per cent. The quantity fed to livestock was less than 4 per cent. and the quantity used for farm manufacture was less than 2 per cent. The higher summer

[1] It should be made clear that any specific costs involved in retail work have been omitted in arriving at cost of production of milk for these herds.

TABLE II.

Cost of Production of Milk (59 Herds).

(28th September, 1935—26th September, 1936).

No. of Cows in Herd	27.33	26.76	27.04
No. of Cows in Milk	21.31	22.21	21.75
No. of Cows Suckling	0.72	0.72	0.72
No. of Cows Dry....	5.30	3.83	4.57
Total Milk Yield (gallons)	461,243	557,929	1,019,172
Yield per Cow in herd (gallons)	286	355	637
Yield per Cow in Milk (gallons) .	367	426	794

	Winter.			*Summer.*			*Whole Period.*		
	Per Cow.	*Per Gallon*	*Per cent. to Total*	*Per Cow.*	*Per Gallon.*	*Per cent to Total.*	*Per Cow.*	*Per Gallon.*	*Per cent. to Total.*
(1) FOODSTUFFS.	£ s. d	*Pence*	%	£ s. d	*Pence*	%	£ s. d.	*Pence*	%
Purchased .. .	4 14 2	3.95	32.03	2 19 6	2.04	26.64	7 13 10	2.88	29.73
Home Grown .	3 9 3	2.91	23.59	0 14 5	0.48	6.45	4 4 3	1.58	16.30
Grazing	1 0 3	0.85	6.91	2 7 6	1.58	21.27	3 7 4	1.26	13.02
Total . .	9 3 8	7.71	62.53	6 1 5	4.10	54.36	15 5 5	5.72	59.05
(2) LABOUR									
Family	1 4 9	1.04	8.44	1 2 2	0.75	9.90	2 6 10	0.88	9.07
Hired . . .	1 13 6	1.40	11.38	1 9 7	1.00	13.26	3 3 0	1.18	12.18
Total	2 18 3	2.44	19.82	2 11 9	1.75	23.16	5 9 10	2.06	21.25
(3) MISCELLANEOUS	1 8 9	1.20	9.78	1 6 6	1.00	11.86	2 15 0	1.05	10.66
(4) HERD DEPRECIATION ...	1 3 1	0.97	7.87	1 3 7	0.80	10.62	2 6 8	0.88	9.04
(5) GROSS FARM COSTS	14 13 9	12.32	100.00	11 3 3	7.65	100.00	25 16 11	9.71	100.00
(6) CREDITS.									
(*a*) Calves ...	0 13 2	0.55	4.51	0 12 10	0.43	5.73	1 6 0	0.48	5.03
(*b*) Manurial Value of Foods	0 17 7	0.74	6.03	0 6 9	0.23	3.02	1 4 6	0.46	4.76
(7) NET FARM COSTS	13 3 0	11.03	89.46	10 3 8	6.99	91.25	23 6 5	8.77	90.21

Disposal of Milk.

	Winter.	*Summer.*	*Whole Period.*
	%	%	%
Sold Wholesale . .	82.90	84.30	83.71
Sold Semi-Wholesale	1.16	0.90	0.98
Sold Retail .	9.48	6.56	7.83
Sold to Employees	0.04	0.01	0.03
Perquisite to Employees . . .	0.12	0.09	0.12
Used in Farmhouse	1.90	1.65	1.76
Fed to Livestock .	3.20	4.24	3.79
Farm Manufacture.			
Cheese	—	0.06	0.03
Butter	0.90	1.01	0.95
Cream	0.30	1.15	0.80
Total	100.00	100.00	100.00

proportions of total production sold wholesale and lower proportions of semi-wholesale and retail are largely due to the higher gallonage in that period. Proportions fed to livestock and for farm manufacture were naturally higher in the summer.

Allowing for the value of the credits, the net expense for the whole period was £23 6s. 5d. per cow and 8.77d. per gallon. This does not include any charge in respect of management or interest on capital employed but covers all farm costs incurred up to the point of cooling. All delivery costs and transport charges are excluded. The value of food including grazing was £15 5s. 5d. per cow and 5.72d. per gallon, the average cost of manual labour was £5 9s. 10d. per cow and 2.06d. per gallon, and other expenses were £5 1s. 8d. per cow and 1.93d. per gallon. Comparison of winter and summer costs show that the cost for the winter period was nearly £3 more per cow and practically the whole of this is due to the difference in the costs of foods. Average winter cost of milk production was 11.03d. as against 6.99d. per gallon in summer. Of this difference of slightly over 4d. per gallon 3¼d. is accounted for in the expenditure on foods (including grazing).

The highest and lowest costs for the fifty-nine herds show very wide variations. For the whole period they ranged from £12 16s. 6d. to £36 0d. 4d. per cow in the herd and from 6.73d. to 13.69d. per gallon. For the winter period the range was from £6 13s. 7d. to £20 18s. 0d. per cow and from 6.13d. to 19.73d. per gallon. Summer costs showed variations of from £4 18s. 4d. to £15 5s. 9d. and from 3.49d. to 11.88d. per cow and per gallon respectively. The main divisions of the general costs are shown below.

	Winter.	*Summer.*	*Whole Period.*
	%	%	%
Foods	63	54	59
Labour	20	23	21
Other Expenses	17	23	20
Total	100	100	100

Cost of Foods.

The cost of food is by far the largest single item in the cost of producing milk, and for these herds represented 59 per cent. of the gross costs for the whole period, 63 per cent. in winter and 54 per cent. in summer. Food costs varied widely and were influenced by the price of the various concentrates bought, the

productive capacity of the herd, and the economy of the rations used. Systems of feeding varied. Grass farms relied entirely on hay and purchased concentrates, others fed cows on a ration consisting of a variety of home grown foods in addition to cake. Some farms bought hardly any foods, others incurred heavy expenditure in feedingstuffs. Rationing strictly according to milk yield was practised on some of the farms, but this was not general. It is now generally recognised that success in dairy farming is intimately bound up with efficient methods of feeding the herds and the milk producer who is anxious to reduce his cost has to study carefully his expenditure on foods, both home-grown and purchased. The art of profitable cow keeping seems to depend very largely upon feeding each individual cow with the exact quantity of food she requires and no more, and that at the least possible cost. In the feeding and handling of the dairy herds, there are many different items which enter into or affect the feeding programme. During winter the cows are fed on a variety of home-grown and purchased foods and the nature of the feeding will mainly depend upon the kind and quantities of home-grown foods available. During the summer, in addition to grass they may be allowed some concentrates. Cheapness in home-grown food depends largely on good yields per acre and efficient utilisation of the foods available. There is a tendency for home-grown foods to be fed with less regard to economy than those which are purchased; especially is this the case when supplies of home-grown foods are plentiful. Again, the nutritive values of the home-grown foods have to be considered. Their value as food will depend on soil conditions, manurial or other treatment of the land, weather conditions during the growing season and at time of harvesting and the conditions under which they are stored. The value of purchased foods will depend on their food value in relation to price at time of purchase and the suitability of selected supplies as feed for dairy cows. The quality and quantity of grass available during summer feeding is another important factor affecting yields and cost and feeding value of pasture will be largely determined by the quality of grassland management. Economical feeding can only be achieved by the careful control of the food consumption of each individual cow and the utilisation of home-grown and purchased foods to the best advantage.

Quantities of bulk foods and concentrates fed (per cow and per 100 gallons) together with the cost are stated in Tables III and IV. These only give average results and the limitations of

the data must be fully recognised. Systems of feeding vary and the nature of the foods used and the quantities fed per cow show considerable differences for these herds. There are some farms

TABLE III.

Quantities of Home-Grown and Purchased Foods fed per Cow and per 100 gallons.

Foods.	*Winter.*		*Summer.*		*Whole Period*	
	Per Cow.	*Per 100 Gallons.*	*Per Cow.*	*Per 100 Gallons.*	*Per Cow*	*Per 100 Gallons*
	cwts.	*cwts.*	*cwts*	*cwts.*	*cwts*	*cwts.*
Hay	20.50	7.17	4.36	1.23	25.04	3.92
Straw	0.89	0.31	0.27	0.08	1.17	0.18
Silage	0.36	0.13	—	—	0.37	0.06
Roots and Green Fodder	10.61	3.71	1.67	0.47	12.37	1.93
Sugar Beet Pulp	0.29	0.10	0.01	—	0.30	0.05
Total Bulk Foods	32.65	11.42	6.31	1.78	39.21	6.14
Home-Grown Corn	0.97	0.34	0.26	0.07	1.24	0.20
Purchased Meals and Cake	13.20	4.62	8.22	2.33	21.48	3.36
Total Concentrates, Home-Grown and Purchased	14.17	4.96	8.48	2.40	22.72	3.56
Minerals	0.04	0.01	0.01	--	0.04	0.01

Quantities of Bulk and Concentrated Foods and Cost of Pasturage per gallon of milk.

	Hay.	*Straw.*	*Silage.*	*Roots and Green Fodder.*	*Sugar Beet Pulp.*	*Total Bulk Foods.*	*Concentrate*	*Pasturage.*
	lb.	*lb.*	*lb.*	*lb.*	*lb.*	*lb.*	*lb.*	*Pence*
Winter	8.03	0.34	0.14	4.15	0.11	12.77	5.5	0.85
Summer	1.38	0.08	—	0.53	—	1.99	2.08	1.58
Whole Period	4.39	0.20	0.06	2.17	0.05	6.87	3.98	1.26

TABLE IV.

Cost of Home-Grown and Purchased Foods fed per cow and per 100 gallons.

Foods.	*Winter.*		*Summer.*		*Whole Period.*	
	Per Cow.	*Per 100 Gallons.*	*Per Cow.*	*Per 100 Gallons.*	*Per Cow*	*Per 100 Gallons.*
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Hay	2 16 3	0 19 9	0 12 1	0 3 6	3 8 8	0 10 9
Straw	0 1 5	0 0 6	0 0 4	0 0 1	0 1 10	0 0 3
Silage	0 0 7	0 0 2	—	—	0 0 7	0 0 1
Roots and Green Fodder	0 6 9	0 2 4	0 1 0	0 0 3	0 7 9	0 1 3
Sugar Beet Pulp	0 1 6	0 0 6	0 0 1	--	0 1 7	0 0 3
Total Bulk Foods	3 6 6	1 3 3	0 13 6	0 3 10	4 0 5	0 12 7
Home-Grown Corn	0 4 5	0 1 7	0 1 2	0 0 4	0 5 8	0 0 11
Purchased Meals and Cakes	4 12 2	1 12 3	2 19 2	0 16 10	7 11 7	1 3 6
Total Concentrates	4 16 7	1 13 10	3 0 4	0 17 2	7 17 3	1 4 6
Minerals	0 0 4	0 0 1	0 0 1	—	0 0 5	0 0 1
Total Bulk Foods and Concentrates	8 3 5	2 17 2	3 13 11	1 1 0	11 18 1	1 17 2
Cost of Grazing	1 0 3	0 7 1	2 7 6	0 13 2	3 7 4	0 10 6
Total Foods	9 3 8	3 4 3	6 1 5	1 14 2	15 5 5	2 7 8

where roots and green fodder do not enter into the ration, others feed as much as 80 lb. per cow per day. Daily rations of hay vary from 10 to 30 lb. and there are herds to which no home-grown concentrates are fed. The results shown in Tables III and IV are, however, useful in that they give some indication of the proportion of bulk foods and concentrates fed and the proportions as between winter and summer.

The average costs of foods for all herds (excluding grazing) is 4.46d. per gallon of which 1.51d. is for bulk foods and 2.95d. is for concentrates. To this must be added 1.26d. for grazing, bringing the total costs of food up to 5.72d. per gallon. Winter costs of 7.71d. per gallon comprise 2.79d. for bulk foods, 4.07d. for concentrates and 0.85d. for grazing. Summer costs of 4.10d. per gallon comprise 0.46d. for bulk foods, 2.06d. for concentrates and 1.58d. for grazing. The difference between winter and summer costs (including grazing) is 3.61d. per gallon and 4.34d. per gallon excluding grazing. During the early part of the summer period some herds were fed indoors and even in those cases where they were out on the pastures, some feeding of concentrates was necessary to supplement the grass in order to maintain milk production. While these conditions are fully appreciated the fact that the expenditure on concentrates during the summer were about one half of costs in winter does suggest low feeding value of pastures and that the judicious application of manures together with well directed efforts to improve the pastures generally would go a long way towards reducing feeding costs.

A large variety of both purchased and home grown foods were used. An analysis of the weights fed, however, indicated that some foods were much more popular than others and that a large number of the foods used were being consumed in comparatively small amounts. The classification of the foods in Appendix I indicates the nature and relative importance of the different products fed.

Of the concentrates fed, about 50 per cent. consisted of various proprietary cakes and meals. Other concentrates of importance were maize meal, flaked maize, palm kernel cake and meal and bran. Maize meal and flaked maize together accounted for 18.36 per cent. of the total concentrates fed in winter and 28.88 in summer. Bran represented slightly over 10 per cent. of the concentrates fed in summer but less than 7 per cent. in winter. The proportion of palm kernel cake and meal was lower in summer (4.68 per cent.) as compared with 7.37 per cent. in

winter. The grains fed were almost entirely home grown and accounted for 7.72 per cent. of the total concentrates in winter and 3.5 per cent. in summer. Of the grains, oats were of major importance. Apart from hay, which constituted the greater part of the bulk food, the feeding of kale figured very prominently during the winter months and accounted for 19.33 per cent. of the total bulk foods. Potatoes, carrots and cabbage amongst the home grown foods were fed in very small quantities and apparently had no part in any organised system of feeding. The same is equally true of silage. Fair amounts of swedes and mangolds were fed and together were responsible for 10.5 per cent. of the total bulk foods fed in winter. Swedes do not appear to have been used during the summer, but mangolds accounted for 18.53 per cent. of the bulk foods. Beet tops were made use of as feed to dairy cows and also beet pulp, but they represented but a small proportion of the total bulk foods fed.

The Supply and Cost of Feed Stuffs.

It has already been explained that all purchased concentrates have been charged at cost, including transport; all home grown foods at values as ascertained on the basis of feeding values and prices of a standard group of feedingstuffs and pasturage at cost as ascertained from total cost of pasturage, less charges to other stock. Values of manurial residues have been deducted at half the theoretical standard from all the purchased and home grown foods. One-third of the yearly rent of pasturage has been allocated to the winter and two-thirds to the summer half of the year.

Agricultural economists in this country have devised and used a method of estimating the total contribution of pastures to the feeding of cows in starch equivalent values and of estimating the cost per unit of starch equivalent of this contribution. Suggestions have been made that pastures provide the cheapest food for cows and that cost of producing milk depends largely on the proportion of the food requirements of cows obtained from pastures.

The method consists of

(1) Estimating the food requirements of the cows (*a*) for maintenance; (*b*) for production, including the requirement of protein in the total of starch equivalent requirements. For this purpose it is necessary either to weigh cows or to assume an average weight.

(2) Estimating the total food requirements supplied by all foods other than pastures (including all concentrates and all bulk foods). The quantities of these foods are known and the protein and total starch equivalent supplies are obtained by applying results of standard analyses to the known quantities.

(3) Deducting the amount of starch equivalent supplied by all other foods from the total amount of food requirements (both for maintenance and production) and taking the balance as the contribution of pasture to maintenance and production.

Thus the method is essentially one of finding the difference between the total food requirements of the cow and the amount of those requirements supplied by hand-feeding and assuming that pastures supply the difference.

The method involves several assumptions, namely :—

(1) That the weight of cows will be approximately as assumed and that the weight will be the same at the beginning and end of the year or at the beginning and end of any period for which the estimate may be made.

(2) That the starch equivalent content of foods other than grass will not vary to any appreciable extent from their theoretical composition and that any under or over estimate of nutritive requirements supplied by the foods will be quite small.

(3) That any allocation of pasture costs between winter and summer on a conventional or customary basis substantially represents the facts of the contribution of pastures to the feeding of cows during these periods.

These are large assumptions. The cows may put on or lose weight : the actual protein and starch equivalent values of foods fed may be higher or lower than has been allowed, and as will be seen later the allocation of pasturage costs tends to throw too high a charge on the winter period.

During the whole year, the average cow in these herds, estimated at a weight of 10¼ cwt. and producing 637 gallons of milk required 4,107 units of starch equivalent with a protein ratio of 1 : 6.68. The actual amounts fed (concentrates and bulk foods) per cow were 2,765 units of starch equivalent with a protein ratio of 1 : 5.37. By difference the contribution of pastures to the feeding of the average cow is estimated to be 1,342 units of starch equivalent and ninety-eight units of protein equivalent.

The position so far is simple. But it may be necessary to ascertain how much pastures contribute to feeding in the winter and summer periods respectively. The conventional and customary methods of allocating pasture costs (when cows are actually at pasture during winter days) between winter and summer, assume that the winter pastures do make a contribution. The allocation from the annual costs (in this case amounting to £1 0s. 3d.) per cow, assumes that the cows obtained food

TABLE V.

Consumption of Starch and Protein Equivalent
(Whole period 28th September, 1935-26th September, 1936—364 days.
Yield per cow in herd = 637 gallons.

	Per Cow.					
	Starch Equivalent.			*Protein Equivalent.*		
	Maintenance.	*Production.*	*Total.*	*Maintenance.*	*Production.*	*Total.*
	lb.	*lb.*	*lb*	*lb.*	*lb.*	*lb.*
Theoretical Requirements*	2,504	1,603	4,107	228	385	613
Actual amounts fed			2,765			515
Deficiency in Starch Equivalent and Protein Equivalent supplied by grazing			—1,342			—98

* Standard figures for maintenance and production requirements have been taken from he Report of the Departmental Committee on the Rationing of Dairy Cows

requirements from pastures of this money value, or at least that cows benefitted from being at pasture during the winter, in food supplies and general health, to the equivalent of £1 0s. 3d. per cow in cost. In this case the first assumption was that food requirements to the value of £1 0s. 3d. per cow were supplied by pastures.

During the winter period the average cow produced 286 gallons of milk and on the original weight of 10¼ cwt. the standard requirements were 1,967 units of starch equivalent with a protein ratio of 1 : 6.87. It is estimated that the actual amounts fed of bulk and concentrated foods supplied 1,932 units of starch equivalent with a protein ratio of 1 : 5.38 and a total of 359 units of protein.

Thus if the weight of the cow remained unchanged, the actual amounts fed (bulk foods and concentrates) indicate an excess in protein equivalent and a deficiency in starch equivalent. The contribution of the pastures to the feeding of the average cow is estimated to be thirty-five units of starch equivalent. On the basis of a pasturage winter cost of £1 0s. 3d. per cow, the cost per unit of starch equivalent is 6.6d. It is possible that the cows

put on weight during the winter months and that feeding for maintenance is more than allowed for in the theoretical requirements, and there is also the possibility of more or less deliberate feeding being in excess of theoretical production requirements for the purpose of stimulating heavier yields of milk. In that case, it may be that the contribution of feeding by pastures during the

TABLE VI.

Consumption of Starch and Protein Equivalent
(Winter period 28th September, 1935-28th March, 1936—182 days).
Yield per cow in herd = 286 gallons.

	Per Cow.					
	Starch Equivalent			*Protein Equivalent.*		
	Maintenance	*Production*	*Total.*	*Maintenance.*	*Production.*	*Total.*
	lb	*lb*	*lb.*	*lb.*	*lb*	*lb.*
Theoretical Requirements	1,252	715	1,967	114	172	286
Actual Amounts fed			1,932			359
Deficiency in Starch Equivalent			—35			
Excess in Protein Equivalent						+73

winter period is higher than indicated by the results in Table VI. On the other hand, it may also be that the estimates of contribution of pastures and therefore of the cost values of pastures are much too high.

TABLE VII.

Consumption of Starch and Protein Equivalent
(Summer period 29th March-26th September, 1936—182 days).
Yield per cow in herd = 355 gallons.

	Per Cow.					
	Starch Equivalent			*Protein Equivalent*		
	Maintenance.	*Production.*	*Total*	*Maintenance*	*Production.*	*Total*
	lb.	*lb*	*lb*	*lb*	*lb.*	*lb.*
Theoretical Requirements	1,252	888	2,140	114	213	327
Actual amounts fed			833			156
Deficiency in Starch Equivalent and Protein Equivalent			—1,307			—171

During the summer period the average cow produced 355 gallons of milk and the estimated standard requirement is 2,140 units of starch equivalent and 327 units of protein equivalent. Actual amounts fed (bulk foods and concentrates) supplied 833 units of starch equivalent and 156 units of protein equivalent, leaving a difference of 1,307 units of starch equivalent and 171

units of protein equivalent to be supplied by pasture. Cost of summer grazing per cow is £2 7s. 6d., which gives a cost per unit of starch equivalent of 0.44d.

TABLE VIII.

Estimated Consumption and Cost of Starch Equivalent. Per Cow in Herd.

	All bulk foods and concentrates fed			*Pasturage on Allocation of Costs to Winter and Summer.*			*Pasturage on all costs to Summer.*		
	Starch Equiv. fed.	*Net Cost.*	*Cost per lb. Starch Equiv.*	*Starch Equiv supplied*	*Cost of Grazing*	*Cost per lb Starch Equiv.*	*Starch Equiv. supplied.*	*Cost of Grazing*	*Cost per lb. Starch Equiv.*
	lb.	£ s d	*Pence.*	*lb.*	£ s. d.	*Pence.*	*lb.*	£ s d.	*Pence.*
Winter	1,932	7 5 6	0.90	35	1 0 3	6.60	—	—	—
Summer	833	3 7 1	0.97	1,307	2 7 6	0.44	1,342	3 7 9	0.60
Whole Period	2,765	10 12 7	0.92	1,342	3 7 9	0.60	—	—	—

If it is true, as appears probable, that the winter pasturage for these herds on the whole makes no contribution to food requirements and that turning out has a value mainly for health and convenience, and therefore that all the actual costs of pasturage should be charged to the summer period, then the cost of pasturage per unit of starch equivalent becomes 0.60d.

The summary of the costs per unit of starch equivalent is given in Table VIII.

The average cost of starch equivalent supplied by all foods during the summer period other than grazing was 0.97d. per lb. as compared with a summer grazing cost of 0.44d. per lb. Assuming that the grazing by these herds in the winter period is valued more from the point of view of exercise than from the amounts of nutrients obtained from the grass and that the total cost of grazing should be charged to the summer period, then the cost of starch equivalent supplied by grazing is 0.60d. per lb. as compared with 0.97d. per lb. for all bulk foods and concentrates fed. For the whole period the cost for all foods other than grazing is 0.92d. per unit of starch equivalent as compared with 0.60d. per unit of grazing. These results therefore indicate that the cost of one pound of starch equivalent supplied by grass is about two-thirds the cost of the corresponding food value supplied by foods other than grazing. If the figures can be taken as representative of the actual feeding values as between grazing and other foods then they do suggest the importance of utilising the grassland to its fullest extent and wherever possible economising in other foods by the substitution of grazing.

An analysis of the various bulk foods and concentrates fed per cow in the herd on the basis of starch and protein equivalent supplied is given in Appendices 2, 3 and 4 and the data covers the full period of fifty-two weeks and the winter and summer periods. From the summary of this data given for the whole period in Table IX it will be seen that while concentrates (which consist mainly of purchased foods) contributed about 42 per cent of the starch equivalent supplied yet hay (apart from grass) was the most important single food fed. The starch equivalent consumed in hay was about 21 per cent. as compared with nearly 20 per cent. for compound meals and cakes which come next in order of importance to hay. In all, practically one-fourth of the total starch equivalent was supplied by bulk foods, so that bulk foods other than hay only contributed approximately 4 per cent. Slightly over 22 per cent. of the starch equivalent was supplied by concentrates other than compound meals and cakes and of these maize

meal, flaked maize, bran and palm kernel cake and meal were the most important. Grass (measured by deficiency) contributed slightly over one-third of the total starch equivalent supplied.

Concentrates with over 60 per cent. of the total supply were much more important than bulk foods which supplied only about 24 per cent. of the total protein equivalent. As in the case of the supply of starch equivalent, hay was again of outstanding importance as a single food with a contribution of nearly 21 per cent. of protein equivalent and only exceeded by compound meals and cakes with a contribution of nearly 31 per cent. Grass (measured by deficiency) contributed about one-sixth of the total protein equivalent.

TABLE IX.

Whole period—52 weeks—364 days.

Summary of Actual Quantity of Starch and Protein Equivalent fed per cow in Herd.

Yield per cow in herd - 637 gallons.

Class of Food.	*Starch Equivalent.*		*Protein Equivalent*	
	lb.	%	*lb.*	%
Hay	865.8	21.08	128.3	20.91
Other Bulk Foods	162.3	3.95	16.4	2.67
Total Bulk Foods	1,028.1	25.03	144.7	23.61
Compound Meals and Cakes ..	805.6	19.86	188.7	30.77
Other Concentrates	930.9	22.43	181.7	29.64
Total Concentrates	1,736.5	42.29	370.4	60.41
Grass (by deficiency)	1,342.0	32.68	98.4	15.98
Grand Total (all Foods) ...	4,106.6	100.00	613.1	100.0

Production Labour.

The quantity of labour used in relation to number of cows varies from farm to farm according to such conditions as size of herd, convenience of buildings both as regards feeding of the cattle and the handling of the milk, the proportion of winter and summer production and the efficiency of the labour.

The production man labour hours for all herds averaged 208 hours per cow per annum. This figure agrees fairly closely with results obtained in similar investigations.(1).

In Table X the hours of labour per cow and per 100 gallons have been analysed according to the size of the herd.

The results indicate that the labour requirements tend to fall as the herds increase in size. The difference between herds averag-

TABLE X.

Size of herd and labour hours per cow and per 100 gallons.

Group.	Number of Herds.	Average No. of Cows in Herd.	Per Cow: Hired Labour.	Per Cow: Family Labour.	Per Cow: Total Labour.	Per 100 Gallons: Hired Labour.	Per 100 Gallons: Family Labour.	Per 100 Gallons: Total Labour.	Yield per Cow in Herd.
	No.	No.	Hours.	Hours.	Hours.	Hours.	Hours.	Hours.	Gallons.
WHOLE PERIOD.									
SIZE OF HERD.									
Under 20 ...	20	15.0	101	129	230	17	21	38	607
20 and under 30	21	24.9	117	163	220	19	17	36	606
Over 30	18	42.7	131	54	185	19	8	27	676
Average	—	27.0	122	86	208	19	13	32	641
SUMMER.									
Under 20	20	15.0	49	59	108	14	17	31	342
20 and under 30	21	24.9	57	49	106	17	14	31	338
Over 30............	18	42.7	60	25	85	17	7	24	362
Average ..	—	27.0	59	43	102	17	12	29	355
WINTER.									
Under 20	20	15.0	52	70	122	20	26	46	265
20 and under 30 ..	21	24.9	60	54	114	22	20	42	268
Over 30	18	42.7	71	29	100	22	9	31	314
Average	—	27.0	63	43	106	22	15	37	286

ing fifteen cows and those of twenty-five cows per herd is small and only amounts to ten manual labour hours per cow per annum.

Herds of thirty and over with forty cows per herd require thirty-five hours less of manual labour per cow per annum than the group of herds of twenty and under thirty cows. Comparison of summer and winter labour requirements show similar tendencies, namely, a reduction in labour from the smaller to the larger herds. Of the labour requirement of 208 hours per cow for all herds for the fifty-two weeks, the distribution as between summer and winter requirements is 102 hours per cow for the summer and 106 hours per cow for the winter period. While these figures suggest a fairly even distribution as between summer and winter labour requirements for all herds the results for the different sized herds show slightly wider differences as between summer and winter labour requirements and in particular in the case of the herds of over thirty cows. Here it is shown that out of a labour requirement of 185 hours per cow per annum, the summer labour was eighty-five and the winter labour 100 hours.

When the labour is considered in relation to the yield of milk produced, the two smaller groups are very similar, the number of hours per 100 gallons of milk produced being thirty-eight for the herds consisting of less than twenty cows and thirty-six for the herds of twenty and under thirty cows. Yield of milk for the two groups is similar and averaged 607 and 606 gallons per cow in herd respectively. For the herds of over thirty cows, the yield was considerably higher and averaged 676 gallons per cow per annum with a labour requirement of twenty-seven hours per 100 gallons. For all herds, labour averaged thirty-two hours per 100 gallons of milk and the average yield was 611 gallons per cow per annum. Owing to the greater yield of milk given in summer the manual labour hours were more in winter and averaged thirty-seven as compared with twenty-nine hours per 100 gallons in summer.

While there are individual cases which show considerable differences as between summer and winter production, the proportion of summer to winter production shows but very little variation as between the different sized groups and for all the herds. In the case of the two smaller herd groups (Under twenty cows and twenty and under thirty cows) the summer production was 56 per cent. as compared with 54 per cent. for the herds of over thirty cows and 55 per cent. for all herds.

Hired labour represented 59 per cent. of total labour employed on the herds, but, as might be expected, the proportion of hired to family labour was less over the smaller sized herds.

Size of Herd and per cent. of Hired Labour.

Size of Herd.	*Hired Labour.*
	%
Under 20 cows	44
20 and under 30 cows	53
Over 30 cows	71
All herds	59

The average cost of labour is 2.06d. per gallon, which is equivalent to £5 9s. 10d. per cow per annum. Variation in cost between one farm and another is considerable. Of the fifty-nine herds, 47 per cent. had labour costs of under 2d. per gallon, 39 per cent. had costs of between 2d. and under 3d. per gallon and 14 per cent. had costs of over 3d. per gallon. When labour costs are stated per cow in herd 38 per cent. of the herds had costs of under £5 per cow, 26 per cent. had costs of £5 and under £6 per cow, 18 per cent. had costs of £6 and under £7 per cow and 18 per cent. had costs of over £7 per cow.

In Table XI the labour costs per cow and per 100 gallons have been summarised according to the size of the herd.

It has already been explained that in assessing the cost of labour, all family labour not actually paid for in cash has been charged at the current rate of wages for hired workers of a similar class. Rates of wages will vary according to the class of labour employed and the proportion of the work done in connection with the herds by women and boys. The variation in the average rate of wages paid per hour for labour in each group of herds is not very great. For the herds consisting of less than twenty cows the rate of wages is 5.9d. per hour and for the group of twenty and under thirty cows the average rate is 6.4d. per hour. For the herds above thirty cows the rate is 6.7d. and for all herds 6.4d. per hour. The lower rates are closely related to the amount of work done by women and boys. Slightly higher rates of wages prevail during the winter months for all the groups.

Winter and Summer Costs.

For all herds there is, practically speaking, hardly any difference between winter and summer labour cost per cow—differences in period labour costs per gallon are due to differences in yield. Differences in yield per cow in herd are due to a small extent to the difference in cows dry and suckling—22 per cent. in winter and 17 per cent. in summer and then to the conditions affecting the yield per cow in milk. These are :—

(1) Relative " freshness " of cows which are milked in summer.

(2) More favourable conditions of temperature, rainfall and sunshine for milk production.

TABLE XI.

Size of herd and Labour Cost per cow and per 100 gallons.

Whole Period.

Group.	Number of Herds.	Average No. of Cows in Herd	Per Cow. Hired Labour.	Per Cow. Family Labour	Per Cow. Total Labour.	Per 100 Gallons. Hired Labour.	Per 100 Gallons. Family Labour.	Per 100 Gallons. Total Labour.	Yield per Cow in Herd.
	No	No	£ s d	£ s. d	£ s. d.	£ s. d.	£ s d.	£ s. d.	Gallons.
SIZE OF HERD.									
Under 20	20	15.0	2 6 6	3 7 5	5 13 11	0 7 8	0 11 1	0 18 9	607
20 and under 30	21	24.9	3 1 11	2 16 3	5 18 3	0 10 3	0 9 3	0 19 6	606
Over 30	18	42.7	3 10 4	1 12 8	5 3 0	0 10 5	0 4 10	0 15 3	676
Average	—	27.0	3 3 0	2 6 10	5 9 10	0 9 10	0 7 4	0 17 2	641
Summer.									
Under 20	20	15.0	0 19 11	1 11 0	2 10 11	0 5 10	0 9 0	0 14 10	342
20 and under 30	21	24.9	1 9 8	1 6 6	2 16 2	0 8 10	0 7 10	0 16 8	338
Over 30	18	42.7	1 12 6	0 15 1	2 7 7	0 9 0	0 4 2	0 13 2	362
Average	—	27.0	1 9 6	1 2 2	2 11 8	0 8 4	0 6 3	0 14 7	355
Winter.									
Under 20	20	15.0	1 6 7	1 16 5	3 3 0	0 10 0	0 13 9	1 3 9	265
20 and under 30	21	24.9	1 12 3	1 9 9	3 2 0	0 12 0	0 11 1	1 3 1	268
Over 30	18	42.7	1 17 10	0 17 7	2 15 5	0 12 1	0 5 7	0 17 8	314
Average	—	27.0	1 13 6	1 4 8	2 18 2	0 11 9	0 8 8	1 0 5	286

(3) The greater "milk forcing" power or the greater milk yielding value of fresh pastures as compared with winter feeds.

The lower costs of production in summer are due to these same conditions. There is less food and labour per gallon in summer because fewer cows are dry or suckling. But in the relation of feed and milk yields these are not only the factors listed above, there is also the fact that the food constituents required by cows in milk production can be produced more cheaply in the form of fresh pasture than in any other form.

Cost of Depreciation.

Of the total number of cows in these herds there were about an equal number of home bred and purchased cows. The actual conditions vary between the purchase of the whole of the herd and rearing the whole, but while nine herds had all been purchased only six herds had all been bred by the owners. Of the cows and heifers added to the herds during the year 65 per cent.

TABLE XII.

Depreciation on Cows (59 Herds).

	Number.	*Total Value.*	*Value per head.*
Valuation at beginning of year.		£ s. d.	£ s. d
Cows	1,620	29,889 11 5	18 9 0
Cows bought	391	6,694 18 9	17 2 2
Heifers transferred in	210	3,574 0 0	17 0 4
Total .	2,221	40,158 10 2	—
Cows sold	562	7,010 9 9	12 9 5
Cows transferred out of Herd . .	33	338 5 0	10 5 0
Deaths	40	17 0 0	0 8 6
Valuation at end of year.			
Cows	1,586	29,016 6 0	18 6 3
Depreciation	—	3,716 9 5	2 6 8
Total	2,221	40,158 10 2	—

Depreciation per cow—£2 6s. 8d.
Depreciation per gallon = 0.88d.

were purchased and 35 per cent. were home-bred. On some farms the cows were passing through the herd rather rapidly and in a few herds all the cows were replaced within the year. On an average it appears from the records that about 31 per cent. of the cows were replaced annually. This indicates that cows were kept in the herd on these farms for slightly over three years. During the year 562 cows were sold and forty died. There were thirty-three cows transferred out of the dairy herds and the majority of these were fattened. The death rate for these herds

was about 2.5 per cent. per annum and nearly 7 per cent. of renewals were necessitated by deaths. It will be seen from Table XII that the average valuation of the cows had fallen by 2s. 9d. per cow and that the cows purchased and heifers transferred into the herds averaged £17 2s. 2d. and £17 0s. 4d. each respectively. Cows sold realised £12 9s. 5d. per head and cows transferred out of the herd £10 5s. 0d. each. Depreciation on the herds will, therefore, be influenced by the difference between the price realised for the cows sold and the price of the cows and heifers drafted into the herds, also by the rate of mortality amongst the cows and the average herd-life of the cows. The average cost of herd depreciation on these farms was £2 6s. 8d. per cow and 0.88d per gallon. The individual farm results vary from small appreciation up to a depreciation of £8 1s. 11d. per cow and 3.57d. per gallon. There are indications that the depreciation is higher on herds consisting mainly of purchased cows than on those herds where the majority consists of home-bred cows. For twenty-nine herds with an average of less than 50 per cent. home-bred cows the depreciation was £2 16s. 0d. per cow and 0.99d. per gallon, while on the remaining thirty herds with an average of 50 per cent. home-bred cows the depreciation was £1 15s. 2d. per cow and 0.71d. per gallon.

TABLE XIII.

Yield of Milk and Depreciation per Cow and per gallon.

Yields.	*No. of Herds.*	*Per cent. Home-bred Cows.*	*Depreciation per Cow.*	*Depreciation per gallon.*
Gallons.	No.	%	£ s. d.	Pence.
Under 500 ...	9	71	1 13 0	0.85
500 & under 600	16	47	2 0 7	0.86
600 & under 700 ..	20	56	2 4 2	0.82
Over 700	14	36	3 1 0	0.95
All herds .	59	50	2 6 8	0.88

The figures given in Table XIII suggest some relation between milk yields and rate of depreciation on cows but no definite conclusions can be drawn from these results. While the depreciation per cow increases from the lower to the higher yields the proportion of home-bred to purchased cows show a tendency to be higher in the lower yielding herds and the probability is that both factors (yield and proportion of home-bred cows in the herds) have contributed to the results indicated.

The cost of herd maintenance is an important factor in a milk production enterprise and one of the problems of the dairy farmer is how to maintain the herd in the most economical way. The records for these herds have shown that some farmers rely on a buying-in policy when recruiting the dairy herd, others maintain their herds with animals of their own breeding, while others practice a combination of the two methods. Certain advantages are associated with each system while on the other hand, both are characterised by certain disadvantages. In the purchase of cows the risk is not limited to the possibilities of milk yield but is largely a matter of the health of the cows bought and the risk of disease not only in the actual animals which are purchased but occasionally in the contamination of the whole herd. The buying-in policy has, however, the advantage that cows can be introduced into the herd at the time they are required and this is an important consideration when milk contracts have to be fulfilled. The rearing policy has the advantage that it obviates to a considerable extent the introduction of disease, but sometimes depletion in numbers of rearing stock through the elimination of unsuitable types and sometimes by deaths may disorganise the whole system. The records for these fifty-nine herds appear to indicate that the rate of depreciation on cows is higher on herds with a high proportion of purchased cows and this is confirmed by previous studies (2). This, however, does not suggest that dairy farmers should refrain entirely from buying cows for herd maintenance, but it does suggest that great care should be exercised in the purchase of cows, not only as regards the milk yielding capacities of the cows purchased but also in the selection of healthy cows. The evidence from the records show that udder troubles, contagious abortion, tuberculosis and other diseases are far more prevalent in those herds where a buying-in policy is pursued than in herds where the farmers breed and rear their own dairy stock.

The final economy of herd maintenance is not, of course, to be measured by cost alone, for the last measure is between the cost and net profit to the farmer. It may be that the higher cost of depreciation which accompanies the higher proportion of purchased cows in the herd is more than compensated for by the higher net profits obtainable from the sale of milk under this system of herd management. At the same time, the care of the health of the herd and the management of the herd in order to avoid a high rate of depreciation merits the serious consideration of every dairy farmer.

Miscellaneous Costs.

The total of miscellaneous expenditure was £4,898 10s. 2d., which amounts to 1.05d. per gallon or £2 15s. 0d. a cow. Winter costs at 1.20d. per gallon and £1 8s. 9d. per cow were higher than summer costs at 1.0d. per gallon and £1 6s. 6d. a cow. The relative importance of the items making up the miscellaneous costs can be seen from the following statement.

	% to Total.
Rental charge for cowshed and buildings	13.2
Upkeep of bull and for service fees ...	19.7
Veterinary and medicine bill	[illegible]
Milking machine expenses	4.1
Moveable dairy equipment, repairs and depreciation	13.7
Consumable dairy stores and general dairy expenses	19.2
Share of general farm expenses	22.3
Total ...	100.0

The items making up these costs vary from farm to farm and their relative importance will depend largely on the standard or method of milk production. In general, the share of the general farm expenses contributes the largest amount to this item of miscellaneous costs and represents an annual charge of about 12s. 4d. per cow. Upkeep of bull includes charge for food, labour and depreciation. Including cost of service fees in those cases where no bull was kept the cost of the upkeep of the dairy bull amounted to 10s. 10d. per cow per annum. Consumable dairy stores and general dairy expenses were about 10s. 7d. and dairy equipment, repairs and depreciation 7s. 5d. per cow. The rental charge for cowshed and buildings averaged 7s. 3d. and veterinary and medicine charges amounted to nearly 4s. 5d. per cow. In considering the item of milking machine expenses it was only on eight of the farms that they were used. Charges in this respect averaged 2s. 3d. per cow over all the herds.

Credits.

Total credits in respect of value of calves born and manurial value of feedingstuffs amounted to £4,033 5s. 2d. or £2 10s. 6d. per cow and 0.96d. per gallon. Of the total credits, manurial residues were £1 4s. 6d. per cow and 0.46d. per gallon. Credits for calves are very similar in winter and summer (18s. 2d. per cow and 0.55d. per gallon as compared with 12s. 10d. per cow and 0.43d. per gallon) which indicate a fairly even distribution of calvings as between the two periods. Owing to the greater quantities of foods fed the value of manurial residues are considerably higher in winter. The records show that there were

1,224 calves born, of which 656 were sold, and 466 retained. There were thirty-seven premature births and deaths accounted for sixty-five. Including premature births the death rate was 8.8 per cent. of total calves born.

Appendix I.

Foods fed during Winter, Summer and Whole Period.

Class of Food.	*Bulk Foods* (*Winter*).	*Bulk Foods* (*Summer*).	*Bulk Foods* (*Whole period*).
	%	%	%
Hay	62.69	69.18	63.72
Oat Straw	2.75	5.41	3.18
Silage	1.12	—	0.94
Swedes	5.91	—	4.97
Mangolds	1.59	18.33	6.82
Potatoes and Carrots	0.90	0.32	0.81
Kale	19.33	4.76	17.00
Cabbage	0.44	0.16	0.39
Beet Tops	1.28	0.80	1.20
Beet Pulp	0.99	0.84	0.97
Total	100.00	100.00	100.00
	Concentrates.	*Concentrates.*	*Concentrates.*
Oats	6.39	2.81	5.08
Barley	1.13	0.48	0.90
Mixed Corn	0.20	0.21	0.20
Total Grain	7.72	3.50	6.18
Compound Cakes and Meals	19.73	51.13	50.19
Maize Meals	9.77	13.66	11.21
Flaked Maize	8.59	9.72	9.01
Palm Kernel Cakes and Meals	7.37	4.68	6.38
Bran	6.68	10.08	7.95
Ground Nut Cake	3.54	2.09	3.01
Soya Bean Meal	3.08	0.95	2.30
Cotton Seed Meal	1.84	3.06	2.30
Decorticated Cotton Cake & Meal	0.66	0.29	0.52
Others	1.02	0.84	0.95
Total	100.00	100.00	100.00

Appendix II.

Actual Quantity of Starch and Protein Equivalent fed per cow in herd. Whole Period 28th Sept., 1935—26th Sept., 1936, 364 days. Yield per Cow in Herd=637 gallons.

Class of Food.	*Starch Equivalent.*		*Protein Equivalent.*	
	lb.	%	*lb.*	%
Hay	865.8	31.36	128.8	25.16
Silage	5.3	0.22	0.6	0.14
Oat Straw .	23.5	0.86	1.2	0.23
Roots	38.7	1.41	2.6	0.51
Green Fodder	73.2	2.66	19.5	2.06
Beet Pulp	21.6	0.78	1.5	0.31
Total Bulk Food ...	1,028.1	37.29	144.7	28.41
Oats . .	75.2	2.76	9.4	1.89
Barley	15.8	0.57	1.3	0.25
Mixed Corn	3.5	0.10	0.3	0.06
Total Grain .	94.5	3.43	11.0	2.20
Compound Cake and Meal .	805.6	29.08	188.7	36.80
Maize Meal . .	238.6	8.63	28.0	5.48
Flaked Maize .	186.8	6.76	20.1	3.95
Bran	145.1	5.19	14.0	2.72
Palm Kernel Cake and Meal	119.2	4.33	31.0	5.29
Ground Nut Cake ...	54.7	1.97	30.7	5.97
Cotton Seed Meal .	43.0	1.55	20.2	3.95
Soya Bean Meal	36.5	1.29	21.7	4.14
Decorticated Cotton Cake and Meal ..	8.6	0.31	4.0	0.88
Others .. .	3.9	0.14	1.0	0.21
Total Concentrates	1,612.0	59.28	359.4	63.39
Total Bulk Foods and Concentrates .	2,764.6	100.00	515.4	100.00

Appendix III.

Actual Quantity of Starch and Protein Equivalent fed per cow in herd. Winter Period 28th Sept., 1935—28th March, 1936, 182 days. Yield per cow in herd = 286 gallons.

Class of Food.	*Starch Equivalent.*		*Protein Equivalent.*	
	lb.	%	*lb.*	%
Hay	713.8	36.95	105.9	29.47
Silage	5.3	0.27	0.6	0.17
Oat Straw	17.1	0.89	0.9	0.25
Roots . ..	29.3	1.51	2.0	0.56
Green Fodder ...	69.5	3.60	10.0	2.78
Beet Pulp . .	18.2	0.94	1.3	0.36
Total Bulk Foods	853.2	44.16	120.7	33.59
Oats . ..	59.8	3.10	7.5	2.09
Barley . ..	12.7	0.66	1.1	0.31
Mixed Corn	2.1	0.10	0.2	0.05
Total Grain .	74.6	3.86	8.8	2.45
Compound Cakes and Meal	498.1	25.78	116.7	32.48
Maize Meal ...	129.4	6.70	15.2	4.23
Flaked Maize	111.5	5.77	12.0	3.34
Palm Kernel Cake and Meal .	86.5	4.48	23.6	6.58
Bran	76.6	3.96	7.4	2.06
Ground Nut Cake ..	40.0	2.08	22.5	6.26
Soya Bean Meal .	30.8	1.60	18.3	5.09
Cotton Seed Meal	21.5	1.11	10.1	2.81
Decorticated Cotton Cake and Meal ..	7.1	0.37	3.3	0.92
Others . ..	2.6	0.13	0.7	0.19
Total Concentrates	1,004.1	51.98	229.8	63.96
Total Bulk Foods and Concentrates ...	1,931.9	100.00	359.3	100.00

Appendix IV.

Actual Quantity of Starch and Protein Equivalent fed per cow in herd. Summer Period 29th March, 1936—26th Sept., 1936, 182 days. Yield per cow in herd = 355 gallons.

Class of Food.	*Starch Equivalent.*		*Protein Equivalent.*	
	lb	%	lb.	%
Hay .	152.0	18.26	22.4	14.39
Silage .	0.0	0.00	0.0	0.00
Oat Straw	6.4	0.76	0.3	0.19
Roots .	9.4	0.13	0.6	0.38
Green Fodder . .	3.7	0.44	0.5	0.32
Beet Pulp	3.4	0.41	0.2	0.13
Total Bulk Foods	174.9	21.00	24.0	15.41
Oats	15.4	1.85	1.9	1.22
Barley .	3.1	0.37	0.2	0.13
Mixed Corn	1.4	0.17	0.1	0.06
Total Grain .	19.9	2.39	2.2	1.41
Compound Cake and Meal	307.5	36.93	72.0	46.21
Maize Meal	109.2	13.11	12.8	8.22
Flaked Maize	75.3	9.05	8.1	5.20
Bran	68.5	8.23	6.6	4.24
Palm Kernel Cake and Meal .	32.7	3.93	7.4	4.75
Cotton Seed Meal	21.5	2.58	10.1	6.48
Ground Nut Cake	14.7	1.76	8.2	5.26
Soya Bean Meal	5.7	0.68	3.4	2.18
Decorticated Cotton Cake and Meal .	1.5	0.18	0.7	0.45
Others . . .	1.3	0.16	0.3	0.19
Total Concentrates	637.9	76.61	129.6	83.18
Total Bulk Foods and Concentrates .	832.7	100.00	155.8	100.00

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THE CONSUMPTION OF MILKSTUFFS AND MEATSTUFFS IN THE RHONDDA VALLEY.

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The material on which the present study is based was collected in certain districts of the Rhondda Valley in the summers of 1934 and 1935. Information relating to the general social, economic and industrial background of the area, as well as statements concerning methods of collection, will be found in previous issues of this Journal (1). It is not assumed that general conditions in the area have or have not changed since the time the material was collected and no attempt is made to relate the facts to conditions obtaining in the present or in any more recent periods than those stated.

In carrying out these surveys of consumption of "milkstuffs" and of " meatstuffs " an attempt was made to get records from the same households on both occasions and a large measure of success was experienced. Out of the 259 households which provided records of consumption of " meatstuffs," 217 had also provided records of consumption of " milkstuffs " a year earlier. Both sets of records were taken and the degree of correlation between income and expenditure on " milkstuffs " per person and between income and expenditure on " meatsuffs " per person was calculated in order to ascertain whether income exercised similar or dissimilar quantitative influences on the expenditure of money on both classes of foods. Previous study has shown that when the class " meatstuffs " is split up into its constituent foods a very variable degree of relationship is obtained between income and expenditure on different foods (2). Taking the class " meatstuffs " as a whole, however, a better and more constant relationship is found because the types of " meatstuffs " entering into household budgets vary as between different households in the same period and the effect of taking all expenditure on " meatstuffs " for the family is to minimise variations in expenditure due to the differences in choices made by consumers according to tastes or in attempts to make incomes meet their needs in the best way. The same course has been adopted with regard to " milkstuffs," for consumers of this class of food also seek the maximum of satisfaction by purchasing what appears to be the best combination of " milkstuffs "; and since consumers at any

given time vary in their judgments as to the proportion of total expenditure on " milkstuffs " the expenditure on any individual type of " milkstuff " should constitute, it follows that the degree of correlation between income and expenditure would show wide variation as between the individual types of " milkstuffs " within that class. It is held, therefore, that the reaction of consumers is shown in a better and more direct way when the expenditure on the two classes of goods are considered without separation.

The correlation coefficient between average income per person and average expenditure on " milkstuffs " per head both measured in the 217 households was $+0.805 \pm 0.043$ which is considered as showing significant positive correlation between the

TABLE I.

Average Consumption and Cost of Milkstuff per Person per week in all households.

Particulars.	*Number of Persons* 1	2	3	4	5	6	7	8	9	10	11	12	14	*Whole Group.*
Number of Households . ..	4	64	106	141	92	69	60	27	20	11	4	3	1	602
Income per Person	14/6	23/4	16/4	13/4	11/1	9/5	0/4	8/6	7/8	6/6	6/2	5/4	5/3	11/5
FRESH MILK . . .														
Pints	2.37	2.85	2 00	1.48	1.33	1.27	0 99	0.63	0.68	0.81	0.32	0.16	—	1.29
Cost—pence ..	7.12	8.68	6.00	4 58	3 91	3.82	2 96	2 01	2 01	2.24	0.95	0.50	—	3.92
CONDENSED MILK :														
Pints M.E.* ..	0.50	0.31	0.45	0 53	0 49	0.45	0.55	0.66	0.71	0 43	1.00	0.25	0.34	0.52
Cost—pence ..	1.50	1.05	1.19	1.33	1.64	1.08	1.35	1.46	1.62	1.06	1.93	0.50	0.69	1.27
MILK POWDER AND MALTED MILK														
Pints M.E. *..	—	0.03	0.13	0 09	0.08	0 06	0.06	0.07	0.48	0.16	0.39	0.47	1.61	0.12
Cost—pence .	—	0.10	0.40	0.38	0 08	0.11	0.13	—	0.35	—	—	—	-	0.19
CREAM :														
Oz	—	1.08	0.78	0.56	0.45	0.45	0.29	0.19	0.21	0.13	—	—	—	0.43
Cost—pence .	—	1.23	0.88	0.61	0.45	0.37	0.28	0.16	0.16	0.12	—	—	—	0.47
PUBLIC SUPPLIES :														
SCHOOL :														
Pints	—	—	0.09	0 10	0.14	0.16	0.22	0 18	0.29	0.54	0.68	0.34	1.53	0 18
CLINICS :														
Pints	—	—	0.04	0 08	0 15	0.25	0.21	0.30	0.33	0.19	0.47	0.58	0.53	0.18
Total Cost** (pence)	8.62	11 06	8 86	7.44	6.95	6.61	6 01	5.07	6.00	5.61	6.33	3.76	6.87	6.93

* M.E.—Milk Equivalent.
** Including estimated value of free supplies of fresh milk.

two factors after allowance is made for the size of the probable error. A year later the same households showed a correlation coefficient of $+0.806 \pm 0.043$ between the factors average income and average expenditure on " meatstuffs " again measured per head. These two results covering the same households are almost exactly alike and seem to establish the fact that income influenced expenditures on " milkstuffs " and " meatstuffs " to about the same degree because general conditions and consumers' prices did not change to any appreciable extent between the two dates on which the surveys were made.

In previous articles dealing with the consumption of " milkstuffs " and " meatstuffs " in the Rhondda Valley no attempt was made to present an analysis of results on the basis of size of households as the details involved could not be incorporated in the space available. A detailed statement is now offered covering both surveys from the standpoint of numbers of persons in households.

Consumption of Milkstuffs.

All Households.

Consumption and cost of " milkstuffs " a head per week is shown in Table I for all households. The vast majority fell into the groups with two to seven persons each. Households with numbers below and above these limits contained few members, but the range was from one to fourteen persons. The influence of high numbers per household on income per person is clearly established, for apart from those with one person each, income fell constantly from 23s. 4d. per person in households with two members to 5s. 3d. per person in that with fourteen members and average income was 11s. 5d. Numbers to be fed in relation to total household income appeared to be an important determinant of the amount and value of " milkstuffs " consumed per person. And it would be true to say that any addition to numbers of persons in households without proportionate increase in income to keep income per person constant or rising, would tend to lead to a fall in the quantity or value of purchases of the best types of " milkstuffs." The Table proves this view to be correct, for there is a continuous though irregular fall in the quantities and values of fresh milk purchased in households with two members and over.

Purchases of condensed milk in terms of quantities and values show rather different tendencies and if anything increase with increases in size of households, although the figures are irregular from group to group. But the smaller households generally consumed the most expensive condensed milk.

The relation of size of household to purchases of milk powder and malted milk cannot be established because much of these were given to some households free of cost and only a minor part was purchased. Only one group of households had no supplies of milk powder and similar preparations.

In another article fresh cream has been called the " aristocrat of milkstuffs," and it seems to be living up to that description, although the statement in the Table includes quantities and values

of both fresh and tinned cream. Households in the size limits two to ten persons were the only ones to purchase this commodity and both quantities and values of purchases decreased as the size of households increased and the cost per unit of cream purchased showed the same tendency. This was due to the fact that the smaller households consumed more fresh cream and less tinned cream than the bigger ones.

The value of "milkstuffs" purchased plus the estimated value of fresh milk received from public sources make up the total value figures in Table I. These figures show rather wide variations between households of varying sizes and no clearly defined downward trend is discernible.

TABLE II.

Average Consumption and Cost of Milkstuffs per person per week in households with adults only.

Particulars	*Adults per Household.*								
	1	2	3	4	5	6	7	8	*Whole Group.*
Number of Households	4	60	67	60	26	8	3	1	229
Income per person .	14/6	23/8	19 1	14/11	12 4	10 2	8/8	6/3	16 5
FRESH MILK :									
Pints	2 37	4.44	1 99	1.65	1 16	2 06	0.86	0.50	1.87
Cost – pence	7.12	8.96	5 99	5 33	3 21	6.06	2.57	1 50	5 66
CONDENSED MILK									
Pints M E.* . .	0.50	0.37	0.45	0.47	0.68	0.26	0.39	0 19	0.47
Cost– pence	1.50	1.04	1 20	1.32	1 69	0 60	0.95	0.41	1.24
MILK POWDER AND MALTED MILK :									
Pints M E.* . .	-	0.02	0 07	0.13	0.05	0.29	—	-	0 06
Cost– pence	--	0.10	0 32	0.36	0.15	0 28		--	0.28
CREAM									
Oz.	--	1.12	0 64	0.52	0.31	0 33	0.43		0 58
Cost – pence . .	—	1.33	0 72	0 56	0 25	0 27	0 62	-	0.62
PUBLIC SUPPLIES : CLINIC									
Pints	–	-	--	0 41	-	--	0.66	--	0.27
Total Cost** ..... (pence)	8 62	11.43	8 23	8 80	5 30	7 21	6 12	1.94	8.61

* M E. - Milk Equivalent
** Including estimated value of free supplies of fresh milk.

Households containing adult members only.

Table II shows the consumption and cost of "milkstuffs" per person in households containing only adult members, which, according to the classification adopted here are persons over fourteen years of age. Most households contained from two to five members. Income per person in all of them was on a relatively higher level than that obtaining in the households in Table I, and the average was 16s. 5d. in the former compared

with 11s. 5d. in the latter. The consumption of fresh milk in households of two to six persons was greater in those containing only adults than in those in Table I but when numbers became bigger than this the opposite was true. Again there was a decrease in consumption as households increased in size, with the exception of those containing six persons, and the average figure for this group was high because one household recorded very high purchases of fresh milk. Consumption of condensed milk showed little variation between households of similar size irrespective of whether the members were all adults or a combination of adults and children. The relation of number of adults per household to average consumption showed two tendencies. Increases in consumption were shown as households increased in size from two to five persons and decreases were shown in those with a greater number of persons. None of the households containing one, seven or eight adults purchased milk powder and malted milk and the average consumption in the others was low and variable.

Households with more than seven or less than two persons bought no cream and consumption declined as size increased. There were no significant differences between the quantities and values of purchases made by households in Table II as compared with those of similar size in Table I.

The only public supplies of fresh milk were obtained from clinics and some of the households with four or seven adults got supplies from this source. Quantities used, however, were extremely small by comparison with the average of all households.

The total values of " milkstuffs " used in households containing adults only showed a tendency to decline with increases in the size of households, but such relationship held only for those with two to five adult members. Again there were no significant differences in the total values of " milkstuffs " used in households of similar size containing only adults and all households. This was particularly apparent when the values of free supplies of fresh milk were added to the values of purchases.

Households containing children.

Table III shows the consumption and value of purchases of " milkstuffs " in households with children below fourteen years old and the classification is made on the basis of the number of children per household. This has been done in order to bring out the relationship between the number of children per household and the consumption of milk per person.

Numbers of households declined as the number of children per household rose from one to ten and the majority contained one to three children. Income per person was distinctly lower in this type of household than in those previously discussed. Average income per person was 10s. 2d. compared with 16s. 5d. for the all-adult group and 11s. 5d. for the whole group and there was a steady decline in income per head as the number of children per household increased from one to seven but the last two groups showed insignificant increases.

TABLE III.

Average Consumption and Cost of Milkstuffs per Person per week in households with Children up to 14 years of age.

Particulars.	*Number of Children per Household.* 1	2	3	4	5	6	7	8	10	*Whole Group.*
Number of Households	157	107	63	20	12	7	4	2	1	373
No. of Persons per Household	4.4	5.6	6.4	9.3	9.2	9.4	8.7	12.0	11.0	5.7
Income per Person..	13/-	10/2	8/8	8/2	6/9	5/10	4/8	5/1	5/3	10/2.
FRESH MILK :										
Pints	1.47	1.17	0.81	0.74	0.62	0.54	0.28	0.16	—	1.09
Cost—pence —	4.51	3.55	2.47	2.24	1.86	1.62	0.84	0.50	—	3.28
CONDENSED MILK :										
Pints M.E.*	0.47	0.52	0.62	0.81	0.41	0.59	0.30	0.25	0.32	0.59
Cost—Pence	1.23	1.24	1.53	2.04	1.01	1.45	0.65	0.50	0.64	1.33
MILK POWDER AND MALTED MILK :										
Pints M.E.* ..	0.07	0.09	0.09	0.21	0.60	0.11	0.69	0.73	1.61	0.15
Cost—pence .	0.22	0.19	—	—	—	—	—	—	—	0.13
CREAM :										
Oz.	0.64	0.44	0.24	0.16	0.15	.	—	—	—	0.40
Cost—pence ..	0.78	0.42	0.22	0.19	0.18	—	—	—	—	0.44
PUBLIC SUPPLIES : SCHOOL :										
Pints	0.13	0.15	0.34	0.26	0.60	0.49	0.57	0.42	1.43	0.25
CLINIC										
Pints	0.10	0.34	0.13	0.27	0.37	0.59	0.40	0.20	0.50	0.23
Total Cost** .. (pence)	7.43	6.87	5.63	6.06	5.96	6.31	4.40	3.13	6.43	6.62

* M.E. Milk Equivalent

** Including estimated value of free supplies of fresh milk.

Average consumption of fresh milk was much below that in the all-adult group and purchases decreased in quantity and value as the number of children per household increased. That is to say, not only did households wholly comprised of adults purchase more fresh milk per person than those comprised of adults and children, but households with the greatest number of children purchased least. This phenomenon appeared to be due to the lowering effect of increases in numbers of children on income per person thereby curtailing purchasing power in relation to

numbers of persons to be fed. Purchases of condensed milk did not make up for the smallness of purchases of fresh milk and only in some groups were the values and quantities purchased significantly higher than in similar size groups for the other types of households. On the whole the tendency was for consumption per person to increase from group to group to households with four children and beyond that point to display irregularities. Consumption of milk powder and malted milk tended to increase with increases in numbers of children per household, but these "milkstuffs" were obtained free of cost in all households except some of those with only one or two children.

No household with more than five children bought cream of any kind. The average quantities and values of purchases were much below those for other groups. Moreover, these declined with every increase in numbers of children per household.

Supplies of milk from public sources were obtained free of cost by some children in schools and by some other persons from clinics. The quantities obtained in this way by households containing children far exceeded those obtained by the other groups. The tendency was for combined supplies from schools and clinics to show increases as numbers of children increased but the trend was irregular.

Total values of "milkstuffs" consumed, after evaluating the quantities of fresh milk obtained from public sources, showed an ill defined trend towards decrease as the size of household was increased by children.

It may be said that the study of the groups of households showed that the one needing most fresh milk purchased least because of restricted purchasing power as expressed by income per person. The same observation is true of purchases of cream and to some extent of condensed milk. But the provision of free supplies of fresh milk and some milk powder, tended to level up the consumption between groups.

As incomes did not rise with increase in size of household the resulting shortage of income in proportion to numbers of persons housewives had to provide for caused restriction of purchases of relatively expensive "milkstuffs" like fresh milk and cream. But the effect on "milkstuffs" like condensed milk and milk powder and malted milk was rather different and inconclusive. There was a tendency, however, for the principle of substitution to be applied and consumers chose the best combination of "milkstuffs" and thus used purchased supplies of fresh and condensed milk, free and purchased supplies of milk

powder and malted milk and free supplies of fresh milk to attain this end. The values of total " milkstuffs " consumed indicate that they experienced a large measure of success in doing this but it was not complete for there still existed rather wide differences in the values of " milkstuffs " per person consumed in households of different sizes.

Consumption of Meatstuffs.

All Households.

The consumption of " meatstuffs " is expressed per adult equivalent, as it is held that adults are more important as consumers of meat than are children under fourteen years old (3).

TABLE IV.

Average Weekly Consumption and Expenditure on " Meatstuffs " per adult equivalent.

Size of Household	2	3	4	5	6	7	8	9	10+	*Whole Group*
Number of Households	31	41	65	58	36	19	16	8	5	259
Average Income per person .	21/1	15/11	12/11	9/10	10/3	9/10	8/6	7/1	6/-	11/3
TOTAL FRESH MEAT :										
Quantity (lb.)	1.36	1.48	1.26	0.98	1.03	0.80	0.98	0.56	0.64	1.08
Cost (pence)	18.06	19.33	16.11	13.45	12.49	9.69	11.80	6.08	8.51	13.73
CURED MEAT :										
Quantity (lb.)	0.46	0.43	0.39	0.34	0.34	0.29	0.38	0.18	0.13	0.35
Cost (pence)	7.33	6.37	5.87	5.13	5.08	4.23	5.22	2.27	1.90	5.22
PREPARED AND TINNED MEAT .										
Quantity (lb.)	0.41	0.32	0.26	0.31	0.39	0.40	0.31	0.37	0.42	0.34
Cost (pence)	4.69	3.38	2.93	2.92	3.60	3.81	2.31	2.95	3.74	3.33
FISH :										
Quantity (lb.)	0.40	0.41	0.35	0.29	0.25	0.27	0.35	0.26	0.22	0.32
Cost (pence)	3.22	3.44	3.12	2.26	2.27	2.65	2.88	2.12	1.43	2.70
EGGS .										
Quantity (oz.)	11.74	11.05	8.72	8.10	7.15	6.06	7.35	5.60	4.27	8.00
Cost (pence)	7.25	6.84	5.43	5.13	4.36	3.75	4.39	3.30	2.70	5.00
Total (lb.)	3.36	3.33	2.81	2.43	2.46	2.14	2.48	1.72	1.68	2.59
(pence) ..	40.55	39.36	33.46	28.89	27.80	24.13	26.60	16.81	18.28	29.98

Table IV shows the consumption and expenditure on " meatstuffs " by a group consisting of all households. Their size ranged between two and twelve persons but the majority contained six persons or less. Income per person averaged 11s. 3d. and showed regular decline as the size of households increased from two members.

Purchases of fresh meat declined almost regularly as the number of persons per household increased, those containing eight or ten being the only exceptions. But this made little difference to the obvious downward trend of consumption.

Quantities of cured meat did not display such regular tendencies, but with the single exception of households composed of eight persons, values of purchases of cured meat did show a tendency to decline in this respect. Consumption of prepared and tinned meat in terms of quantities and values showed a tendency to vary between the households of different sizes and no well defined trend was established. Quantities of fish consumed showed a tendency to decrease irregularly from the smaller to the bigger households but values showed a more definite tendency to do this; households with eight persons were again the only exception. The same tendency was true of quantities and values of eggs, but households composed of seven or eight persons were exceptions to the rule.

Total quantities of "meatstuffs" consumed declined from 3.36 lb. per adult equivalent in the households with only two persons to 1.68 lb. in those with ten persons. The decline was regular save for small irregularities in households with six or eight persons. Values of total purchases of "meatstuffs" expresed in the same way declined regularly from 3s. 4½d. to 1s. 6¼d. with the sole exception of households with eight persons.

TABLE V.

Average Consumption and Expenditure on Meat, Fish and Eggs per person per week for households of Adults only.

Size of Household (Adults)	2	3	4	5	6	*Whole Group.*
Number of Households	30	18	29	13	7	97
Average Income per person	21 6	17 0	13 3	8 10	10 7	14 2
TOTAL FRESH MEAT						
Quantity (lb.)	1 35	1 49	1.21	0 79	1 09	1.18
Cost (pence)	18 11	18 92	15 09	11.75	13.64	15 42
CURED MEAT:						
Quantity (lb.)	0 47	0 43	0.42	0 31	0 22	0 30
Cost (pence)	7 51	6.42	6.32	4 80	3.37	5.89
PREPARED AND TINNED MEAT:						
Quantity (lb.)	0 41	0.32	0.15	0.25	0 39	0 27
Cost (pence)	4 80	3 52	1 58	2.52	4.03	2.95
FISH:						
Quantity (lb.)	0 41	0.33	0.28	0.28	0.19	0 30
Cost (pence)	3.30	2.76	2.47	2 13	1.39	2.46
EGGS:						
Quantity (oz.)	11.66	11.40	8 25	5.58	6.81	8 67
Cost (pence)	7 23	7.07	5.04	3.57	4.09	5.35
Total Quantity (lb.)	3 37	3.28	2.57	2.01	2 31	2.68
Cost (pence).	40.95	38.69	30.50	24.77	26.52	32.07

Households containing only adult members.

Since these households contain only adults, figures in Table V are given per head.

All households of this type fell between the size limits of two to six persons. The number in each size group showed some irregularity and income declined as the size of household increased except in those with six adults where a marked increase in income was displayed but the average income was considerably higher than in the whole group being 14s. 2d. as compared with 11s. 8d.

Average consumption of fresh meat in the adult group was higher in terms of quantities and values. And it is extremely important to notice that except in one case quantities and values of purchases declined as households became larger. It appears that as income per person in size group 6 was higher than in the previous one no restrictive effort was imposed by income despite increase in the size of household. Purchases of cured meat were little higher in this type than those in all households and declined regularly from the smaller to the bigger households —even in those with six persons, which is contrary to what happened with fresh meat. On the whole, appreciably less prepared and tinned meats were consumed in households composed of adults as compared with others. Quantities and values of this kind of " meatstuff " showed no clear trend in relation to numbers in households. But fish, consumed in least quantity by the adult group, showed regular decline in values and quantities with increases in size of households. Adult households again consumed most eggs and purchases showed a regular decline in values and weights from the smaller to the larger households except those with six persons.

Average values and quantities of the total " meatstuffs " generally declined with the increase in the size of households, the range between high and low in terms of weight and value of " meatstuffs " consumed was 2.01 lb. to 3.37 lb. and 2s. 0¾d. to 3s. 5d.

Households composed of adults and children.

Households containing children were of sizes ranging from two to twelve persons and the most representative number fell between the size limits two to eight persons. Apart from one household with only two persons incomes declined steadily from the smaller to the larger and average income per person was only 10s. 3d. as compared with 14s. 2d. in the adult group.

Average consumption of fresh meat was very much lower than that for all households and quantities and values declined with increases in size except in the cases of households with eight or ten persons. Values and quantities of purchases of cured meat

declined as households increased in size with the single exception of those containing eight persons. Consumption of prepared meat was higher in this type of household than in any other and again there was no clear relationship between numbers in households and quantities or values of purchases. Exactly the same features characterised the consumption of fish. Eggs were consumed by households of all sizes but average consumption was much below that found in those consisting of only adults. The quantities

TABLE VI.

Weekly Consumption and Value of Meat, Fish and Eggs per Adult Equivalent in households with Children.

Persons per Household.	2	3	4	5	6	7	8	9	10+	*Whole Group.*
Number of Households .	1	23	36	25	29	19	16	8	5	162
Income per Person	7/6	15/1	12/8	10/4	10/2	9/10	8/6	7/1	6/4	10/3
Adult Equivalent per Household	1.50	2.37	3.17	4.09	4.81	5.47	5.83	6.37	7.55	4.30
FRESH MEAT :										
Quantity (lb.)	1.83	1.48	1.29	1.09	1.01	0.80	0.97	0.56	0.66	1.02
Cost (pence)..	16.00	19.73	17.06	14.53	12.14	9.69	11.80	6.07	8.51	12.87
CURED MEAT :										
Quantity (lb.)	—	0.42	0.35	0.34	0.38	0.29	0.37	0.18	0.13	0.33
Cost (pence)......	-	6.32	5.38	5.34	5.59	4.23	5.22	2.27	1.90	4.88
PREPARED AND TINNED MEAT :										
Quantity (lb.)	-	0.32	0.35	0.35	0.39	0.40	0.31	0.37	0.42	0.36
Cost (pence)	—	3.23	4.24	3.17	3.47	3.81	2.31	2.95	3.74	3.41
FISH										
Quantity (lb.)	--	0.49	0.43	0.31	0.27	0.27	0.35	0.26	0.22	0.33
Cost (pence)	—	4.11	3.76	2.33	2.54	2.64	2.88	2.12	1.43	2.81
EGGS										
Quantity (oz.)	14.56	10.56	9.12	9.60	7.20	5.92	7.20	5.60	4.16	7.52
Cost (pence)	8.00	6.60	5.80	6.61	4.44	3.75	4.39	3.39	2.70	4.82
Total Quantity (lb.) .	2.74	3.37	2.99	2.69	2.50	2.13	2.45	1.72	1.69	2.51
Cost (pence) .	24.00	39.99	36.24	31.98	28.18	24.12	26.60	16.80	18.28	28.79

and values of eggs consumed declined regularly as households became larger but the sequence was broken by those comprised of eight persons.

The general tendency was for consumption of total "meatstuffs" in households containing children to decrease with increase in size and this occurred with regularity except in the case of quantities in respect of households containing seven persons and in the case of values in respect of those containing seven or over ten persons. The range between the highest and lowest consumption and expenditure was wide, being 1.69 lb. to 3.37 lb. and 1s. $4\frac{3}{4}$d. to 3s. 4d.

Conclusion.

Purchases of "milkstuffs" and "meatstuffs" showed high positive correlation to income. Consumption of "meatstuffs" varied in relation to types and sizes of households. Those composed wholly of adult members consumed more of the better and protective kinds of "meatstuffs" than those containing adults and children. Some members of the latter households must have suffered from the lack of protein foods of a protective character such as eggs, and it is probable that in households with adults working for low wages the chief sufferers on this account were children because of the prevalence of the practice of feeding the breadwinner irrespective of the needs of other members. Average consumption also declined as households increased in size in both types. But it is quite clear that this effect would work far more havoc in households with children than in those without them because the latter were much larger. It follows that increases in size of household, though always affecting consumption, caused really serious problems in those with several children. The fact that the larger households tended to consume more prepared and tinned meat as well as fish than smaller ones is proof of this. These kinds of "meatstuffs" varied enormously in value per unit weight and thus afforded opportunities for housewives to purchase foods to make up bulk or give savour to other and less attractive articles of diet. Support is given to the argument that consumption varied inversely with size of household only when increase or decrease in numbers of members caused increase or decrease in income, because increase in consumption occurred when size of household and income per person moved in an upward direction. This tended to show that the influence of income on purchases was stronger and more direct than size of household. That is to say, given the necessary income per person households of varying sizes would have shown a more regular rate of consumption. The consumption of "milkstuffs" showed precisely the same trend as that for "meatstuffs" though values of the latter were much greater than those of the former, but for each person a high proportion of income was spent on these two foodstuffs. It may be said that type and size of household influenced consumption mainly in so far as they affected income per person.

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HOUSEHOLD BUDGETS IN THE RHONDDA VALLEY.

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Introduction.

Household budgets provide information about the income getting and the income spending activities of people and communities. The purpose and value of studying them is to discover factors and combinations of factors influencing the consumption of goods and services by human beings. Such information is valuable in so far as it forms a basis for initiating improvements in modes and standards of living of society, as a whole, or of certain groups within it. But these studies are valuable not only as guides to necessary reforms in consumption but also as indicators of the relative importance of the " elements " forming the sum total of consumption of households living on similar or differing social and income planes. The " elements " of consumption may be regarded as food, clothing, shelter, fuel and lighting and certain optional items such as education, insurance, etc. It is important to producers who expend time, labour and money in producing articles to satisfy these wants to know the effects of increases or decreases in income on the market for the goods they produce. It is also important that they should know what effects increases or decreases in consumption of any of the different " elements " will have on the market for the others. Likewise, agriculturists can gain considerably from knowledge of tendencies of the effects on the market for food of greater or lesser consumers' expenditure on other goods and services of a non-food character, for it is clear that the greater the amount of income spent on food the less the amount available to buy other things and *vice versa*. Demand for food is exceptionally strong as it is one of man's primary wants. The proportion of man's activities which goes to satisfy this want varies with different types and in different stages of society and with different groups

within it. With the development of the productive arts the proportion which must needs be spent on foods has tended to diminish, thus setting free time to develop other forms of activity and means to acquire new habits of consumption. This feature is of fundamental importance in a surplus economy. Under present conditions the demands for food and different kinds of foodstuffs are in turn the products of strong economic and social forces, which determine directly how much money shall be spent on food and indirectly how much shall be used to buy other things. But in virtue of its absolute necessity food is given pride of place in budget statements despite the fact that the proportion of total income used to buy it tends to decline in the most progressive communities as incomes increase. Studies of complete household budgets are necessary from the agricultural standpoint because the existence of abnormally heavy expenditures on items of a non-food character may explain the failure of certain sections of consumers to purchase as much food or of as good quality as may otherwise be permitted by conditions of food prices and incomes.

Again food itself is a convenient name for a number of nutrients all having the power in different degrees of affording sustenance to any living organism. Food can be divided into various categories, but the most recent broad division is that between energy giving and protective foods. Foods of these types must be included in every satisfactory system of diets. The proportions of each type used are important and there is a tendency to say that large masses of people are living on diets badly balanced in this respect. This is equivalent to saying that either the food raised is unsuitable to physiological requirements, or even if the food needed is produced it cannot reach consumers in the correct proportions due to the lack of purchasing power, defective knowledge of values, strong prejudices or high prices. But consumers are still selecting a combination of foods which, according to their standards of judgment, form the best combinations giving the maximum satisfaction under given conditions. The only way of ascertaining the reasons for the behaviour of consumers in relation to purchase of food materials is examination of all the items of foods used during a given time in relation to social classes and incomes.

Inquiries into the consumption of special groups of foods like "milkstuffs" perform useful functions so far as they go and practical and valuable results have been obtained from their use.

But used without certain safeguards they are extremely dangerous in so far as they do not show the relation of consumption of a particular food to the consumption of foods as a whole. Household budgets eliminate this very serious limitation of any statement of consumption of single or closely allied groups of foods.

How serious the practical errors may be as a result of use of material showing only part of expenditure on foods can be illustrated from recent work in this field. In a part of the Rhondda Valley it was found that out of 11s. 5d. of income per person 2s. 7½d. was spent on "milkstuffs" and "meatstuffs" (excluding butter and cheese from the former and including fish in the latter). The proportion of income spent on these foods therefore is high and this is a characteristic of communities with substantial incomes and high standards of living. As compared with some people living in countries with other geographic, economic, and political environments a relatively poor group in the Rhondda Valley show evidence of high and expensive consumption of foods. At the same time incomes in this area are low and social conditions are poor relative to those which are found in other parts of this country. In this most distressed of areas the mass of the people have been and still are living in comparative poverty. It is of interest to enquire why they showed a tendency to consume some articles of food in a way much more characteristic of wealthy than of poor communities.

Some general reasons for this behaviour of consumers are known. When a community begins to obtain greater command over natural resources and to develop advanced technical methods of exploiting them, early efforts are directed to increasing food supplies, then to increasing variety, and later to improving qualities. In a stratified society these changes take place at different times and at different rates, but where there are no rigid taboos each class down the social scale tends to raise its standard towards that of the class immediately above as general incomes rise, or as changes in distribution of incomes give each class its opportunity. Having achieved a given standard each class, and most of the individual households in each, strives to maintain it. Economic setbacks like unemployment compel households to make certain adjustments in expenditures, and in varying degrees these are made to secure supplies to meet physiological needs, or to meet primary requirements, and then to meet certain social needs and generally in the endeavour to maintain health, energy, and some

social standards. But consumers, like producers in similar circumstances, have some obligations like rent which are of contractual character, and adjustable only with difficulty. According to knowledge, prejudices, preferences, fear of or respect for neighbours, with some socially acquired needs of varying pressure, and individual, family, and social valuations of primary and social necessities each household makes adjustments in expenditure to meet changes in incomes and expectations of income. These changes are of multiple and complex character.

Hitherto it does not appear to have been possible to study these changes *in process* or *in movement* as they occur from the dynamic causes, but it has been possible to make inferences about them from studies of expenditures of households in different circumstances at a given time. It has been felt therefore that the collection of a small number of records of household expenditures extending over a considerable period of time would be of special value, but for the moment the static method is in use and comparisons are made between groups of households suffering in two different degrees from unemployment and another group in which the " heads " are employed.

The statement offered is preliminary and it is proposed to extend this work after discovery of the best methods of collection and analysis of records. Statements of expenditure on all goods and services were obtained from forty-six households in the Rhondda Valley for the month of July, 1936. Households of varying types were visited and heads were asked to fill in and return record forms provided by the Department.[1] Little assistance was given in the actual work of recording after the purpose of the forms had been explained.

Consumption and Employment.

The average number of persons per household was 4.5 and over 62 per cent. of income was derived from wages or businesses, about one-quarter of it from public assistance and quite small proportions from pensions and other sources.[2] But the sources from which incomes were obtained varied considerably in different types of households as is shown in Table I.

[1] Department of Agricultural Economics, University College of Wales, Aberystwyth.

[2] Average size of households, proportion of income by sources, and average expenditure on " milkstuffs " and " meatstuffs " agree very closely with the results of previous surveys. (See Appendix).

About 45 per cent. of the households had no member earning wages and about 90 per cent. of income was obtained from social sources. In eight of the households with heads unemployed there were other members earning wages, and this group showed less reliance on income from social sources and more on income from wages. Nearly 97 per cent. of income in households with heads in employment was derived from wages or business. The table, therefore, shows gradation from very heavy reliance on social income in the first group to almost complete reliance on earnings in the third group.

TABLE I.

Sources of Income (Per Cent.)

Particulars.	*Head Unemployed with no Supplementary earners.*	*Head Unemployed with Supplementary earners.*	*Head Employed.*	*Whole Group.*
	%	%	%	%
Business Income	—	—	11.4	6.6
Wages	*3.0	65.3	85.2	56.4
Unemployment Insurance	65.6	23.4	2.8	25.5
Public Assistance ...	11.0	9.6	—	6.4
Pensions	9.9	1.7	0.6	3.5
Other	7.5	—	—	2.2
Total	100.0	100.0	100.0	100.0

* One person in this group performed occasional "odd jobs."

The income and expenditure accounts of these households demonstrated that considerable ingenuity was being exercised in making the accounts balance. That is to say, in those households with the lowest incomes there was a tendency for expenditure to exceed incomes, but not by very much. Generally these were households with the greatest numbers of unemployed members. Those with members working fared a little better and by exercising considerable thrift in expenditure some part of income was saved. But this was done more out of fear for the future rather than from any obvious margin or any easy method of saving. It may be said that some saving was done when it was socially undesirable because householders had to do without necessaries in order to save. Experience of lack of work of any kind in the last few years has made people in this area extremely cautious and particularly vigilant with regard to all items of expenditure. And when work is available attempts to save are

made in order to recover some part of resources which have been lost as a result of prolonged unemployment. This is a strong factor tending to curtail spending and more particularly some forms of it.

The proportion of expenditure on the various items differed in households of varying types. In those with little or no unemployment about 40 per cent. of expenditure was on food, 10 per cent. on clothing and the remainder on other things. Where unemployment prevailed almost 50 per cent. was on food, about 10 per cent. on clothing and slightly over 40 per cent. on other things. Expressed as proportions of income, the figures in the former group would fall to about 38 per cent. for food and in the same ratio for the other items, and the new item would account for the proportion of income saved; in the latter group, however, no change in the proportions is possible because expenditure exceeded income. Thus the group with the lowest income had perforce to spend the greatest proportion on food despite the fact that it was spending slightly beyond its immediate means.

The percentage of expenditure on the various types of goods and services is shown in Table II.

TABLE II.

Proportion of Expenditure on all items.

Particulars.	*Head Unemployed with no Supplementary earners.*	*Head Unemployed with Supplementary earners.*	*Head Employed.*	*Whole Group*
	%	%	%	%
Food . . .	49.2	47.8	42.1	45.4
Rent and Rates .	17.8	14.0	14.3	15.7
Fuel and Lighting	7.8	5.3	7.4	7.1
Clothing	7.5	13.2	10.1	9.9
Insurance . .	5.1	5.3	3.5	4.4
Personal . . .	3.5	3.7	6.7	5.8
Soap and Laundry	2.2	1.6	2.3	2.1
Thrift Clubs . .	1.8	1.7	1.6	1.7
Books, Library, Subs.	1.3	1.7	1.7	1.6
Medical and Chemist	1.3	1.6	3.0	2.1
Other	2.5	4.1	7.3	4.2
Total	100.0	100.0	100.0	100.0

The same grouping has been adopted as in Table I. Those households where there was no wage earner were the weakest economically, while those where the head was in employment

were considerably better off than the ones where the head was unemployed but contained one or more supplementary earners. After food, rent and rates were next in order of importance. Although there was a tendency for this item to rise with advancing economic status, there are grounds for believing that rent and rates are a first charge on income and that other expenditures are made after this necessary payment has been met or allowed for. Smaller proportions were expended on fuel and lighting and clothing. Insurance appears to be quite an important item, especially in groups 1 and 2. The first three groups, moreover, are in order of rising economic status, and of rising expenditure. As the Table represents the distribution of total expenditure it follows that equal proportions represent slightly rising expenditures, and rising proportions represent steeper increases, and *vice versa*. It is observed that as spending power increases a greater proportion of income is spent on "optionals." Expenditure on food is therefore of outstanding importance.

Facts relating to expenditure on different kinds of foodstuffs, numbers of households and persons, types of households and average incomes are set out in Table III

The households with all members out of employment and those with almost all members in employment contained about the same number of persons --4.3 to 4.2; those with the heads unemployed but containing supplementary earners were bigger and contained about 5.6 persons. Incomes were lowest in the unemployed groups and varied inversely with the intensity of unemployment; the group with almost all members employed received very much higher incomes and these varied directly with the intensity of employment. Total expenditure on food varied from 17s. 5½d. to £1 6s. 6¾d. That is to say, the persons living in enforced idleness spent over 9s. per month less on food than the more fortunate of their fellow men. The wealthiest group spent most on meat, eggs, and "milkstuffs," but there was remarkable similarity in expenditures on fish, though expenditure on foods of animal origin always accounted for more than half of the total expenditure on foods. Households with most members employed also spent most on fresh fruit and vegetables. Nearly all these foods are considered to have important protective functions in human nutrition, and it is clear that employed persons could buy these in much greater quantities than the unemployed persons. But some households in which unemployment was heavy spent as much, and sometimes more, on bulky and cheap foodstuffs than those in which members were almost all

employed. Expenditure on cereals and other breakfast foods and butter and cheese and margarine were outstanding in this respect. Practically all these foods were cheap and relatively bulky, and it was largely from liberal use of these that the unemployed households supplied bodily needs. Some of these foods perform protective functions, but in the main they supply energy to the body. Expenditure on fresh vegetables, including potatoes, was

TABLE III.

Expenditure on Foodstuffs per Person per Month.

Type.	*Head unemployed without Supplementary earners.*	*Head unemployed with Supplementary earners.*	*Head in Employment.*	*Whole Group.*
No. of Households	21	8	17	46
No. of Persons	90	45	72	207
Average Income per Person . .	£1 16 6	£2 11 9	£3 17 9	£2 14 2
	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Meats, Suet, Fish, Eggs . .	5 0½	6 1¼	7 10¼	6 3
Cereals and Breakfast Foods .	2 11	4 9	3 8¼	3 7
Butter, Margarine and Cheese	3 4½	4 6½	1 4½	3 11½
Milkstuffs	1 4¼	1 4	2 6	1 9¼
Fruit	7¼	9¼	1 11¼	1 1¼
Vegetables	1 8¾	1 7	2 2¾	1 10½
Preserves .	1 3¼	1 10½	2 1½	1 8½
Beverages	1 0	1 5½	1 6½	1 3½
Home Produced Food and meals from home .	1	1 0	2¾	4¼
Total . .	0 17 5½	1 3 5½	1 6 6¾	1 1 11¼

not much different in households suffering from much or little unemployment, but that on the more "protective" kinds of foods was very deficient in the former as compared with the latter. Recent increases in prices of foods purchased in greatest quantities by the unemployed will tend to make their expenditure relatively heavier on these, and there will be still less money available for buying the more protective kinds of foods. Increases are also occurring in prices of other things, and these will also tend to force the most unfortunate in the community to buy less and less of foods which they most need.

Thus, unless incomes are increased in some way, there must be further decline in the amount of money spent on the most neces-

TABLE IV.

Expenditure on Foodstuffs per Person per Month by Income Groups.

Number of Households	16	15	5	4	3	2	1	46
Number of Persons	85	64	20	14	12	9	3	207
Income per Person per Month ...	*£1 and under £2*	*£2 and under £3*	*£3 and under £4.*	*£4 and under £5*	*£5 and under £6.*	*£6 and under £7.*	*£7 +*	*Average Whole Group.*
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Meats, Suets, Fish and Eggs ..	4 2	5 11	8 7¼	9 6	9 6	11 1¼	15 2½	6 3
Cereals and Breakfast Foods ...	2 10	3 10	3 7¼	6 1	3 7½	3 9¼	7 7	3 7
Butter, Margarine and Cheese	3 5½	3 6½	4 1¾	7 4	4 5	5 5	5 9¼	3 11½
Milkstuffs	1 1¼	1 8¼	2 4	2 6½	3 2	2 11½	4 3	1 9¼
Fruit	4¾	9¾	2 5¾	1 7¼	2 9	2 10	5 1¼	1 1¾
Vegetables	1 6¼	1 8½	2 6	1 11¼	3 6¾	2 3¾	2 2¾	1 10½
Preserves	1 2½	1 9¾	1 6¾	2 2	2 5¾	3 3¼	3 10¼	1 8½
Beverages	11¼	1 3	1 6	2 9	1 11	11½	3 3½	1 3½
Home Produced Food and meals from Home	2¾	9¼	—	—	—	3¼	—	4¼
Total	0 15 10½	1 1 4	1 6 9	1 13 11	1 11 5	1 12 11½	2 7 4	1 1 11¼

sary foodstuffs and if this change is sufficiently widespread it must have some reaction on relative prices in the markets for the foods of protective character.

Income and Expenditure on Food.

The influence of income on expenditure on foods is shown in Table IV. The majority of the households showed incomes ranging from £1 to £3 per person; numbers in the remaining groups were small and incomes ranged from £3 to £7 and over. Income varied inversely with size of household in the first two groups, but this did not occur in groups earning over £3 per person except the last one. Expenditure on meats tended to increase with income, but more so for meats other than fish. Similar tendencies were shown for expenditures on cereal and breakfast foods and for commodities like butter, cheese, margarine and eggs. The value of " milkstuffs " showed almost continuous and substantial increases from the lower to the higher income groups and those for preserves showed an unbroken upward trend. Expenditure on fruit and vegetables showed some irregularity but generally tended to rise with incomes. In fact there were no foods the expenditure on which did not increase with income, but there was a tendency for expenditure on different commodities to show varying rates of increase in response to increases in incomes and in the cases of some commodities the complete response in this respect was reached much sooner in the income scale than in the cases of others. But taking all the expenditure on foods for each group there were substantial differences between the groups. Households in the second income group spent about 5s. 6d. per person more than those in the first, and the third group spent 11s. more. The next three groups spent almost twice and the last group almost three times as much as the first group. The rate of increase in total expenditure on foods is much lower than the rate of increase in incomes.

The overwhelming importance of expenditure on " meatstuffs " in all households is quite clear, but the importance of dairy produce (including " milkstuffs ") and cereal and breakfast foods is also marked. But a study of Table IV brings out similar features to those discussed in the section on consumption and employment. The most poverty stricken households are the ones which obtain least of the necessary nutrients and increases in the prices of the bulkier and cheaper foods must result in less money being spent on the more desirable kinds of food.

The position is that the lower income groups while having less income per head than any of the others, but having about the same food needs per head, cannot sacrifice all the non-food expenditures. They attempt to satisfy approximately the same food requirements at a lower cost per head. The attempt takes

two forms—first some redistribution of the total purchasing power allocated to foods as between the different classes of foods, and second a change from a better to a lower quality, and from higher to lower price commodities, within some of the classes like "meatstuffs" and "milkstuffs." The redistribution causes reduction in quantities and proportions at some points and increases at others; but, strangely, the change from a higher to a lower quality and price within one class may occasionally cause change to a higher from a lower quality in another class. The total of adjustments in a change from a higher to a lower income and a higher to lower expenditure on foods is by no means simple or merely quantitative: at various points it involves subtle changes in qualities. There are some requirements and demands which are relatively stable and others are highly adjustable. In the circumstances under discussion, the demand for bread will be fairly stable, or it may increase slightly, but in any case the *proportion* of expenditure on bread will rise. But in the *cereals* group, there may be goods like cake, biscuits, or some breakfast foods on which expenditure will be reduced. In the case of vegetables, the almost universal item—potatoes—will generally tend to show a fixed demand, and if there is any change there may be an increase because of reduction of supplies of other vegetables; but in any case with a fairly fixed demand for potatoes there is a tendency for the *proportion* of expenditure on vegetables to increase as total expenditure is reduced.

Consumers placed in such predicament will always have to choose those foods which appease hunger in the greatest degree. Housewives in such positions attempt to get the necessary satisfaction and nutriments from the cheapest foods, but when the costs of these rise the markets for other foods, other commodities and services, must suffer if incomes fall or remain stationary. While it is true that consumers, particularly those in poor circumstances, suffer first, this suffering must be communicated ultimately to producers through the ordinary mechanisms of markets.

General Expenditure and Income.

Of the expenditure on goods and services of non-food character that on rent and rates was the most important, followed by the items clothing, heating and lighting, insurance and thrift clubs. The remaining expenditure was spread over many items which may be called conventional necessaries. The proportions of expenditure on rent and rates and thrift clubs mainly for purchase of goods or holidays varied inversely with income, while

the reverse was true of the items clothing, insurance and conventional necessaries. Expenditure on heating and lighting was relatively constant in all income groups, but there are some special conditions of supply of fuel in the Rhondda district. Total expenditure on wants of the non-food type tended to increase at a much greater rate than incomes, and thus increased more rapidly than expenditure on food in response to improvements in material circumstances. But the real relationship of incomes to expenditure on non-food wants cannot be determined without studying budgets for a longer period than one month, because some expenditures on such products or services tend to vary widely in amount and to occur at irregular intervals. The only satisfactory way of removing the results of sudden increases in expenditure is by averaging them over fairly long periods of time.

Conclusions.

It may be said by way of summary that the community studied showed that large numbers of people in it were spending more money than they were earning while others managed to save just a little. But this saving was done, in the main, because households feared the continuation or re-emergence of unemployment with its consequent hardships. Not all saving was done because there was real capacity to save. For all types living in the community 40 to 50 per cent. of total expenditure was on food and the proportion varied inversely with the wealth of the households. Examination of sources of income, more particularly as regards employment and unemployment, showed that these had important influences and though the proportion of total expenditure used for purchase of food declined as average income rose, the actual expenditure increased. Expenditure on food by income groups confirms this view. Employment and unemployment, high incomes or low incomes, again influenced the proportion of expenditure on the better types of foodstuffs, and generally employment and high income and high expenditure on the better kinds of goods seem to be closely and positively associated, for there was more of a tendency to buy less of the protective foods among the poorer sections of the community studied. Present increases in prices must intensify this tendency so long as incomes remain unchanged or are lowered. Should the incomes of the poorer people rise then they will be able to cope with increases in the prices of those bulky foods which are fundamentally necessary to their satisfaction and still spend as much as they do now on better kinds of foodstuffs. And unless this occurs there must be a continuation and perhaps intensifica-

tion of the anomalous position of plenty of protective foods on the market but restriction of purchasing power preventing consumers from buying what is relatively the cheapest food. For this restriction of spending power can be intensified equally by restriction of income and by increases in prices of goods which consumers must buy. So far as this study goes it points strongly to the conclusion that both these influences are now operating and that the latter is assuming increased importance. Furthermore this fact as well as seasonal factors may account very largely for the small decline in the proportion of income spent on " meatstuffs " as compared with a previous study. But the relationship of income to expenditure on any goods or services cannot be determined exactly when practically half of a community is spending slightly beyond its means and running into debt at a particular time. When the inquiry has been conducted for a sufficient length of time the influence of indebtedness on expenditure over long and short periods can be more accurately determined.

APPENDIX.

Comparison of Some Results of Budget Studies in the Rhondda Valley. Expenditure, etc., per Week.

As this is the third study of expenditure *inter alia* on foodstuffs in the Rhondda Valley, it seems desirable that a comparison of some of the chief conditions and results should be presented in order that similarities and differences may be indicated.

Average.	*Full Budget (Present Study).*	*Milkstuffs Study.**	*Meatstuffs Study.*†
	1936.	*1934.*	*1935.*
No. of Persons per Household	4.50	4.83	4.78
Household Income	£2 15 8	£2 15 11¼	£2 13 7
Income per Person	£0 12 4	£0 11 5	£0 11 3
Expenditure on Milkstuffs:	d.	d.	d.
Per household .	23.83	28.25	circa 28d
Per person .	5.29	5.85	—
Expenditure on Meatstuffs:			
Per household ...	107.06	—	119.60
Per person	23.79	—	25.02
Sources of Income:	%	%	%
Salaries and Wages .	63	61	61
Unemployment Insurance	25	30	30
Public Assistance .	6	4	4
Pensions and Other	6	5	5

* E. Ll. Harry Consumption of Milk in a Distressed Area of South Wales. This *Journal*, Vol. XI (1935).

† E. Ll. Harry. Meat Consumption in the Rhondda Valley. This *Journal*, Vol. XII (1936).

THE OPERATION OF THE MILK MARKETING SCHEME IN WALES, 1935-6.

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Increase in the efficiency of production is a characteristic feature of the agriculture of this country during recent years. While this improvement is in itself desirable, it does not follow that it will automatically turn out to be an unqualified benefit to producers. In the long run increase in productive efficiency is advantageous to producers only in so far as they succeed in disposing of the increased output which is likely to occur at such a price as will yield a return sufficient to cover costs of production along with a normal margin of profit, and then retain some of the increase in consumers' supplies arising from efficiency. It may well happen that an increase in production, due to increased efficiency or otherwise, will force down prices to an unremunerative level, and thus prove detrimental to producers' interests. The terms on which farmers exchange their products are therefore of vital importance as it is upon the success of these processes of interchange that their business achievements are measured and on which their potential if not their actual standards of living depend. In other words, the problem of marketing has to be solved, and as the conditions governing production, distribution, and consumption are continually changing it is apparent that in the interests of the farming community the marketing structure should be modified or perhaps re-modelled so that it may provide for the harmonious working of the dynamic elements involved in the situation.

During the years just prior to the advent of the Scheme the condition of the milk market was such as to render some form of organised marketing essential in the interests of all sections of the industry. Many factors contributed to a partial collapse of the market, among which may be mentioned the steady increase in production, which was brought about both by the increase in the size of the dairy herd, and also by an increase in the yield per cow. But there was no corresponding expansion in the demand for liquid milk. This was also a period of falling world prices, those of imported dairy products suffering a severe and almost a continuous decline from about 1925 onwards. The raw

material values of milk for manufacture into butter, cheese, and other milk products fell to very low levels, while there was much undercutting in the liquid market. By 1933 the position had become so acute that it was felt that the collective bargaining methods then employed were inadequate to meet the situation. In October of that year the Milk Marketing Scheme was adopted.

Three full years have now elapsed since the Scheme began to function, and, although there has been a good deal of criticism of its effects, the true criterion is provided by the ways and degrees to which producers have responded to the price conditions existing under the Scheme. It is true that some producers have been adversely affected, but it was not the intention of the Scheme to preserve intact for all producers the *status quo* of normal pre-Scheme days, nor could such a result have been widely expected. The returns of all producers in the aggregate have, however, increased, and, although it is not possible to predict with any degree of accuracy what the position of producers would have been and might now be in the absence of the Scheme, it may be safely stated that by preventing a further decline in producers' prices, and by eliminating direct competition between the liquid and manufacturing markets, the Scheme has been of appreciable service to producers.

As the operation of the Scheme in Wales during 1934-5 was dealt with last year[1], the present account is primarily concerned with the contract year 1935-6, although in order to illustrate the effects of the Scheme on producers in Wales, and to bring out the relative positions of the Welsh regions, data relating to previous contracts will be used for purposes of comparison.

In the years just prior to the advent of the Scheme there had been quite an appreciable increase in the cow population of England and Wales, and, although it has continued to increase into 1936, it is at a much reduced rate. In 1933 the size of the national dairy herd was 9.3 per cent. greater than in 1930, while the annual increases during the three successive years have only been in the region of 1½ per cent. It appears therefore that taking all regions in the aggregate the most rapid expansion took place before the institution of the Scheme. The position in different regions, however, shows much variation. The numbers of dairy cows in North Wales showed an increase of 6.2 per cent. in 1933 over 1930, but in the two following years the reverse process had

[1] This *Journal*, Volume XII.

set in. In South Wales the rate of increase during the former period was about half as great as that for the whole country, and for the next two years it was only just below the national figure. The position in the West Midland, which includes Monmouth, throughout these years was somewhat similar to that for England and Wales.

Numbers of registered producers, of wholesale contracts registered, and of producer-retailers have increased since the commencement of the Scheme, although there are considerable variations in the increases in these items between different regions. The percentage increases between December, 1933, and March, 1936, are given below.

TABLE I.

Increases in Numbers of Contracts and Licenses.

	North Wales.	*South Wales.*	*West Midland.*	*All Regions.*
	%	%	%	%
Registered Producers	29.0	10.8	11.3	12.8
Wholesale Contracts	40.2	39.1	7.2	16.1
Producers-Retailers	38.2	32.5	10.8	35.8

Producer-retailers have shown the largest increase, those for the two Welsh regions, the West Midland, and the average for all regions having increased by almost one third. The increase in the number of registered producers in North Wales and in numbers of wholesale contracts both in North and South Wales have been well above the average for All Regions. Numbers of licensed producer-retailers were specially increased by the withdrawal of exemptions in October, 1934, and the increase in each region is considerably affected by the numbers previously exempted. The increase in the number of wholesale contracts in the West Midland, however, has been rather slower than in England and Wales. The South Eastern was the only region which showed a decrease in the number of wholesale contracts over the same period, while it also showed a decrease of 4.2 per cent. in the number of registered producers. Level Delivery and other Special Service Premium Contracts have shown general reductions, but the special advantages in North and South Wales appear to have declined rather faster than in the whole country. The relative importance of the regions with which we are con-

cerned may be seen from the following Table which refers to March, 1936 :—

TABLE II.

Relative Sizes of Regions in Milk Marketing.

	North Wales.	*South Wales.*	*West Midland.*
	(Per cent. of total in England and Wales).		
Registered Producers	4.32	6.78	8.86
Wholesale Contracts	2.07	6.41	8.76
Producer Retailers	4.76	5.15	7.92

These ratios have remained practically unchanged for South Wales and for the West Midland since the commencement of the Scheme but in the case of North and South Wales the proportions of registered producers and of wholesale contracts have increased slightly.

In 1934-5 total contract sales increased by 19.1 per cent. over those for the first contract year. During 1935-6 they again increased although at a much reduced rate. They advanced from 853,705,000 gallons in 1934-5 to 899,551,000 gallons in the last contract year, an increase of 6.3 per cent. This reduction in the rate of increase in sales under wholesale contracts has been general. In North and South Wales, which registered very high increases in the second contract year, the annual increases for 1935-6 were 4.9 and 7.3 per cent. respectively. The actual gallonages were 19,354,000 for North Wales and 36,032,000 for South Wales. In the West Midland they advanced by 7.6 per cent. from 74,680,000 gallons in 1934-5 to 79,453,000 gallons in 1935-6. The proportionate annual increases in liquid and manufacturing sales in the last two contract years are set out below. The North and South Wales regions have been grouped together.

TABLE III.

Changes in Sales: Increases and Decreases from previous year.

	1934-5. over 1933-4.			*1935-6. over 1934-5.*		
	Wales	*West Midland*	*All Regions*	*Wales*	*West Midland*	*All Regions*
	%	%	%	%	%	%
Total Contract Sales	+ 35.2	+ 16.8	+ 19.1	+ 5.7	+ 6.3	+ 6.3
Liquid Sales ...	+ 13.9	— 4.7	+ 5.3	— 3.5	+ 7.6	+ 0.9
Manufacturing Sales	+ 79.4	+ 11.1	+ 56.6	+ 19.7	+ 5.3	+ 13.5

It will be observed that the annual rate of increase in total liquid sales for 1935-6 was not maintained, the increase being less than 1 per cent. as against 5.3 per cent. for the previous year. In Wales the comparatively high increase in 1934-5 was followed by an actual decrease, which was due entirely to a decrease of over a million gallons in South Wales. In North Wales liquid sales were up by 3.7 per cent. The West Midland, however, showed one of the highest increases during the last contract year. Manufacturing sales have continued to increase at a much higher rate than have liquid sales, although in this case again the rate was reduced in the last contract year. In the West Midland the rates of increases have been lower than those for the whole country, but for Wales the reverse is the case. The rate of increase in contract sales in Wales during the three years has been a good deal greater than in all regions in the aggregate. There might be a tendency to infer that this was due to changes in cow population. Such, however, is not the case as the indications are that there was little, if any, connection between changes in cow population and changes in sales. Thus in the Far Western Region, where sales have increased most, there has actually been a decline in cow population. The increased sales in this and the Welsh regions has been due to a change in the utilisation of milk previously manufactured or otherwise used on farms. This is borne out by the fact that the "sales per cow" in North and South Wales and in certain other remote regions where there have been very marked increases in sales are still only about half as great as those for regions in which sales have not increased so rapidly. It is possible that there will be yet further increases in sales of milk from these "high increase" regions, for reasons which may be dependent on the policy of the Board, on the one hand, and for reasons which lie outside its control on the other.

In order to give stability to the industry the Scheme contains provisions which guarantee all producers a market for their milk. Rigid minimum prices are also fixed for liquid milk and also some pooling of the returns from liquid milk. This latter feature gives a measure of protection to the near-in producers and a measure of advantage of pooling to the more distant producers. Hitherto it has not been the intention to establish a national pool or a national flat-rate price, although this could have been done much more simply. The purposes of the regional pooling systems were those of obtaining measures of control and of equity between producers in the relatively advantageous and in relatively disadvantageous positions, and of giving the near-in producers a

measure of protection in their markets while giving the distant producers some compensation for restriction of competition.

The working of the pooling system entirely depends on the amounts taken from the advantageously situated producers and given to those producers whose farms are more distant from consuming markets. If the pool prices approach a national flat-rate, producers in the near-in regions may say that they do not obtain from pooling any appreciable advantage, and they might further say that they are in a worse position than would arise in the absence of the Scheme. On the other hand, the producers in Wales and the other outlying regions with more varying production are placed in an advantageous position and such as they could not expect to reach in the absence of the Scheme. The main question as regards the levies and the net-contribution to the Inter-Regional Compensation Fund must relate to the rates of levies, and the amount of net contribution, and the relative effects of these on Wales and its producers, with their effects on the near-in regions and their producers.

It was evident from the commencement that owing to the main characteristics of the milk industry in North and South Wales and the proportion and the chief uses of their surplus milk these regions would receive some measure of advantage from the pooling arrangements. During the three contract years that have elapsed the two Welsh regions and the West Midland have received more out of the Inter-Regional Compensation Fund than they paid into it by way of levies. For the first contract year North and South Wales obtained a net benefit of £8,764 and £27,955 respectively, while that for the West Midland was £199,740. The corresponding figures for the second year were £61,558, £18,423, and £299,421 respectively. Expressed per gallon of total contract sales the net benefits from the Compensation Fund for these two years were as follows :—

	1933-4	*1934-5.*
	d.	*d.*
North Wales	0.15	0.80
South Wales	0.27	0.13
West Midland	0.75	0.96

These three regions also obtained considerable net benefits from the Fund during the last contract year. Other regions which enjoy special advantages owing to their proximity to great concentrations of liquid demand were called upon to make net-contributions to the Inter-Regional Compensation Fund, which may be looked upon as payments to help maintain the pool prices

of the less favoured regions and also as the price paid for protection. Thus in the Southern region net contributions on the basis of contract milk amounted to about 0.6 pence per gallon in the first and 0.82 pence in the second year.

The nominal contract prices for liquid milk have continued to increase. For the first contract year they were fixed at 14s. 4d. per dozen monthly gallons for the South Eastern and 13s. 9d. for the remaining ten regions. This distinction was not maintained during the succeeding contracts, the corresponding prices for the second and third contract years being 15s. 1d. and 15s. 3d. "per dozen" respectively for all regions. This equalisation moreover goes some way towards removing the degree of protection which the Scheme was intended to give to the more favoured regions, and thus towards placing all regions on a more equal footing. The increase in the 1935-6 contract prices was effected by raising the October, November and March prices by one penny, thereby maintaining the peak prices throughout the winter period.

This nominal average price of liquid milk, however, will never be likely to be the exact actual average realised price over the whole country because of the variations in quantities sold from month to month at the different monthly prices. A complication also arises through the Milk in Schools Scheme and other forms of assisted sales. Taking these factors into consideration the weighted average realisation value of liquid milk for the whole country during 1935-6 was 15.03 pence per gallon as against 14.87 pence in the previous contract year. The seasonal distribution of sales in North Wales during 1935-6 were almost identical with that for the whole country at 49.6 per cent. for the winter months. The proportion for the West Midland was slightly in excess, and that for South Wales rather below this figure. Taking all factors into consideration the weighted average realisation values for North and South Wales and for the West Midland were 15.06, 14.98 and 15.09 pence respectively.

But the relative proportions of liquid and manufacturing sales are important owing to the separation of these two markets and the very big differences in the realisation values of the milk consigned to each.

Although the consumption of liquid milk has increased somewhat, it has not kept pace with the increase in production. Growing proportions had consequently to be diverted into the manufacturing market. Since the commencement of the Scheme liquid

sales have increased by about 33,300,000 gallons, while manufacturing sales have gone up by almost 150,000,000 gallons. Expressed in another way, manufacturing sales have, since the Scheme came into being, increased about four and a half times as fast as sales of liquid. While the increases in supplies to this market have been general there are wide variations in the manufacturing proportions of different regions. Those for the Welsh Regions, the West Midland, and the averages for the whole country are set out in the Table below.

TABLE IV.

Proportions used for Manufacture.

	1933-4.	*1934-5.*	*1935-6.*
	%	%	%
North Wales	32.36	52.50	53.05
South Wales	32.59	37.97	46.01
West Midland	43.82	51.18	53.62
All Regions	26.89	35.34	38.07

The manufacturing proportions for Wales and the West Midland region were and remain very much higher than the average for All Regions. During 1935-6 that for the West Midland was only exceeded by the Mid-Western and Far-Western regions, the proportion in the latter being 64.71 per cent. The burden of manufacturing milk has continued to increase, especially so in view of the continued low prices of milk products, although this loss has been partly met by payments under the Milk Acts.

The actual value realised for manufacturing milk depends on the relative proportions which go into the different categories and their individual realisation values. These factors are set out in the Table below (p. 102).

The proportion which went to butter and cheese at 61 per cent. for the whole country was slightly higher than in the previous year while that for fresh cream was slightly lower. The average utilisation value for " manufacturing " for 1935-6 over the whole country increased by 0.12 pence from 4.81 pence per gallon in 1934-5 to 4.93 pence in the last contract year. The subsidy worked out at ½d. per gallon as against 0.89 pence in 1934-5, so that the actual realisation values (inclusive of subsidy) for the last two years were 5.68 and 5.43 pence respectively.

The proportions which went into butter making in North and South Wales were somewhat similar to that for the whole country, but those for cheese were considerably higher. In both these regions over four-fifths of the surplus milk went into these two

particularly low-priced classes. The proportions which went into the more remunerative cream class were very low, and had declined slightly from the previous year. The average realisation values for North and South Wales were therefore lower than the average for the whole country and stood at 4.45 and 4.31 pence respectively. The West Midland, on the other hand, achieved a more remunerative utilisation of its manufacturing milk and recorded an average utilisation value of 4.98 pence.

TABLE V.

Utilisation of Milk for Manufacturing Purposes, 1935-6.

Products.	*Percentage of Total.* *North Wales.*	*South Wales.*	*All Regions.*	*Average Utilisation value per gallon.*
	%	%	%	(*pence*).
Butter	30.3	34.5	34.2	3.75
Hard Cheese	53.5	52.8	26.9	4.35
Soft Cheese	—	—	0.3	7.50
Condensed Milk	15.1	1.4	16.3	6.00
Condensed Milk for Export	—	—	3.3	5.00
Milk Powder	—	5.2	3.8	4.50
Fresh Cream	1.1	2.1	11.7	7.50
Bottled Cream	—	0.3	0.1	7.50
Tinned Cream	—	3.6	2.4	6.00
Ice Cream	—	—	0.2	7.50
Sterilised Milk for Export	—	—	—	—
Other Goods	—	0.1	0.8	9.00
Total or Weighted Average	100.0	100.0	100.0	4.93*

* Excluding subsidy; including subsidy 5.43d.

The returns from the sale of manufacturing milk are, however, pooled for the whole of England and Wales, so that the utilisation values for different regions are of only slight practical significance. Although the values for the Welsh regions were slightly lower, and that for the West-Midland slightly above the general average they were all credited with the same value, which worked out at a little under $5\frac{1}{2}$d. inclusive of subsidy. But the benefit obtained from this pooling arrangment should be borne in mind by the milk producers of Wales when making an assessment of the value of the Scheme.

A feature which calls for attention is the continued increases in manufacturing sales, which in some regions have attained very large proportions. It appears that in certain regions the prices received by producers have been higher than would have been necessary to call forth the optimum quantity of milk. The

actual values realised from sales of " manufacturing " have also been very low, and as the greater part of the burden of the difference between costs of production and the raw material value of the surplus is borne by the liquid market, it has a depressing effect on the pool price. An improvement in the prices of imported dairy produce would have the effect of raising manufacturing realisation values, but it is doubtful even then how far this problem of surplus milk would be solved under the existing arrangements.

The margins between the nominal contract prices for liquid milk and the actual pool prices are for the most part made up of payments to equalise the different prices received for liquid and manufacturing sales. Since the commencement of the Scheme the nominal liquid prices have increased, while it is seen that there has been a large expansion in manufacturing sales. The pool deductions have consequently shown quite appreciable increases, the actual amounts varying with the relative changes in the proportions sold for liquid consumption and for manufacturing purposes, and their realisation values. The unweighted pool deductions for the three years are given below. As would be expected those for Wales and the West Midland were somewhat higher than for the country at large. The weighted figures were, however, somewhat lower than the above in each case.

TABLE VI.

Yearly Average Pool Deductions.

Year.	*North Wales.*	*South Wales.*	*West Midland.*	*All Regions*
	d.	d.	d.	d.
1933-4	1.95	1.80	2.20	1.77
1934-5	3.18	2.73	3.31	2.88
1935-6	3.77	3.58	3.83	3.54

The class of producers who are chiefly concerned with the amounts of the deductions are the producer-retailers, as the levies which they are called upon to pay to help maintain the pool prices of their respective regions are for the most part governed by the size of the pool deductions. Therefore producer-retailers' contributions have risen in approximately the same ratio as the deductions. The actual gross levies during the contract year 1935-6 for the two Welsh regions and for the whole country are given in Table VII.

The gross levies for the country at large during the last contract year increased by about three-fifths of a penny per

gallon. The increase for North Wales was slightly below and that for South Wales slightly above this figure. The average for the West Midland for 1935-6 was 3.34 pence, and represented an increase of nearly one halfpenny over the previous year.

TABLE VII.

Producer-Retailers' Levies, 1935-6.

Month.	*North Wales.*	*South Wales.*	*All Regions.*
		Pence per gallon.	
October	3.31	3.12	3.18
November	3.50	3.12	3.23
December	3.25	3.06	3.03
January	3.31	3.12	3.17
February	3.31	3.31	3.21
March	3.75	3.75	3.65
April	4.19	4.00	3.92
May	3.00	2.81	2.78
June	2.81	2.62	2.59
July	3.00	3.00	2.86
August	3.00	3.00	2.84
September	3.06	2.87	2.96
Unweighted Average	3.29	3.15	3.12

But these gross rates do not represent the actual contributions of all producer-retailers, nor the average rates of contribution over a region. Producer-retailers may qualify for the level delivery and the accredited premiums which during 1935-6 were each fixed at a penny per gallon. Taking these factors into consideration the average net rate of levies were as follows:—

TABLE VIII.

Net Levies on Producer-Retailers.

Year	*North Wales*	*South Wales.*	*West Midland*	*All Regions.*
	d.	d.	d.	d.
1933-4	1.01	0.89	1.24	0.89
1934-5	2.27	1.92	2.40	1.99
1935-6	—	—	—	—

As the main factors which influence the pool prices have been discussed, we are now in a position to consider their general level, and the relative position of the milk producers of Wales.

During 1934-5 sales and values per gallon of liquid milk slightly exceeded those of the previous year. There was a considerable increase in manufacturing sales accompanied by a small reduction in realisation values; this, however, was more than

offset by the increase in the Government subsidy. Producer-retailers' contributions also showed quite an appreciable increase. The net effect of changes was to raise the pool prices slightly from 11.83 pence in 1933-4 to 11.99 pence in 1934-5. During 1935-6 manufacturing sales again showed a much greater proportional increase than liquid sales, while the average realisation value for manufacturing milk inclusive of the subsidy showed a slight reduction. The weighted average pool price for this last contract year was just under 11½d. per gallon, a decline of a half-penny a gallon from the previous year. These values, together with certain other results for 1935-6, are set out in the Table below.

TABLE IX.

Contract Prices, Realisation Values, and Pool Prices, 1935-6.

	North Wales.	*South Wales.*	*West Midland.*	*All Regions.*
	d.	d.	d.	d.
(1) Average Nominal Prices for Liquid	15.25	15.25	15.25	15.25
(2) Actual Realised Values for Liquid	15.06	14.98	15.09	15.03
(3) Average Utilisation value for Manufacturing	4.45	4.31	4.98	4.93
(4) Credited to Region (excluding Subsidy)	4.93	4.93	4.93	4.93
(5) Credited to Region (including Subsidy)	5.43	5.43	5.43	5.43
(6) Weighted Average Pool Price	11.10	11.36	11.12	11.48

Although every region obtained a higher pool price in 1934-5 than in the first year, the reverse was the case for 1935-6. Those for North Wales and the West Midland were almost identical at just over eleven pence, while that for South Wales at 11.36 pence was rather below the average for the country at large, although it was slightly over the national figure was 1934-5. But the quite considerable net contributions which both North Wales and South Wales and the West Midland receive from the Inter-Regional Compensation Fund should be borne in mind. In the early part of 1935 a new principle was introduced into the allocation of the Compensation Fund, when it was provided that the difference between the highest and lowest pool prices shall not exceed one

penny per gallon. This principle was strictly adhered to during the last contract year

Numbers of accredited producers continue to increase, although progress in this direction has not been as fast as might be expected. The relative positions of North and South Wales and the West Midland are given in the Table below.

TABLE X.

Numbers and Proportions of Accredited Producers.

	North Wales.		*South Wales.*		*West Midland.*		*All Regions.*	
		%		%		%		%
October, 1935	553	4.9	343	3.0	871	7.7	11,228	100.0
March, 1936.................	650	4.2	570	3.7	1199	7.8	15,350	100.0
October, 1936	802	4.2	825	4.3	1365	7.2	18,930	100.0
Per cent. Accredited to Total within Region, March, 1936	13.1		6.3		9.2		9.9	

During the period to which the data in the above Table relate the greatest increases appear to have occurred in South Wales, where at the commencement progress was rather slow. The proportion of accredited to total producers in South Wales is also below the average for the whole country. The position in the West Midland is somewhat similar to that for the country at large, but in North Wales the proportion is greater.

The accredited levy averaged $\frac{1}{3}$d. over the contract year 1935-6. Receipts from the accredited fund. however, vary according to the proportions of accredited sales to total sales. During this same contract year South Wales received back slightly less than $\frac{1}{6}$d., the West Midland just over $\frac{1}{4}$d., and North Wales almost $\frac{3}{5}$d.

The problem of milk marketing is seen to involve many complicated issues. We have on the supply side the producers who desire to be suitably remunerated for their efforts. On the other side we have the forces of demand represented by the general consuming public and other buying interests. The vital question is how these two apparently divergent interests might be equitably served. From the point of view of producers the solution might be thought to rest in providing answers to the following questions :—

(1) How to maintain or raise the level of wholesale contract prices.

(2) How to raise retail prices without restricting demand, or how to maintain the existing level of retail prices while extending demand.

(3) How to raise the utilisation value of manufacturing milk.

On the first question it is worth noting that the raising of contract prices has not had the desired effect on pool prices. When in 1934-5 the price per gallon was raised by 1⅓d. (from 13s. 9d. to 15s. 1d. " per dozen ") the increase in the pool price was less than ¼d. a gallon, but producer-retailers' levies increased by over a penny. When in 1935-6 contract prices were again raised to 15s. 3d. " per dozen " the pool price actually fell, although producer-retailers' contributions increased by about ¾d.

In the second place it is well known that milk consumption is largely a question of purchasing power and that among the lower paid classes the quantity consumed would increase with a reduction in price. It appears to be true, however, that there is a certain amount of dislike and a certain lack of appreciation of milk as a food. But it would seem unwise to raise retail prices still further. Since the commencement of the Scheme the average retail prices for England and Wales have increased by over 12 per cent., and since 1932-3 by over 25 per cent. The increase in large towns has been rather greater than that in small towns. The position in Wales is not known, but it is very probable that retail prices have shown increases equal to the averages.

Again, the question of raising the utilisation value of manufactured milk would give rise primarily to the problem of competing supplies of butter and the influence of the existence of an efficient substitute. But the temporary solution of these problems would soon bring up the other problem, how to control and curtail the supply of milk. It seems unlikely, however, that the general public in this country would accept a dual policy of State support of prices by subsidy or tariff, and control with restriction of production under statutory powers.

The objective should, on the other hand, be to increase liquid consumption, and this will only be accomplished by a judicious use of the power of price-fixing. Representatives of producers may fix prices while they proceed on sound information on the relations between price and demand and while they have a lively appreciation of the different kinds and degrees of reactions which consumers may make to the prices which are fixed. In view of the fact that liquid sales which represent about two-thirds of total sales contribute about four-fifths of the total revenue, it is apparent that any action which affects this market adversely would be " killing the goose that lays the golden egg."

AGRICULTURAL CO-OPERATIVE SOCIETIES IN WALES, 1933-34-35.

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It is encouraging to find that the agricultural co-operative movement in Wales continues to show steady progress. In 1934 an analysis was made of the financial transactions of the societies dealing primarily in farmers' requirements between 1930 and 1932.[1] It is now proposed to continue the general analysis to the close of 1935, and as a result it may be possible to trace the general developments over the last six years.

The total number of societies has remained unchanged although in other ways considerable progress has been made. Existing societies have grown in size; on the whole they function over wider areas than was formerly the case. This is true of both the marketing and requisite societies and is undoubtedly evidence of healthy change.

TABLE I.
Agricultural Co-operative Societies in Wales.

Year.	*No. of Societies.*	*No. of Members.*	*Turnover.*
			£
1933 ..	83	25,998	1,168,508
1934 ...	83	26,046	1,285,452
1935 ...	83	26,709	1,469,823

The membership shows a gradual rise; the cash turnover advanced by 10 per cent. in 1934 and by a further 14.3 per cent. in 1935.

The years 1933 to 1935 have seen a slight improvement in the general agricultural conditions of Wales. Prices of farm products rose slightly whereas those of raw materials such as feeding-stuffs and fertilisers remained at very favourable levels. Many producers changed their systems of farming during these years. With the advent of the Milk Marketing Scheme there was a widespread desire to enter the milk market as the financial returns obtainable under that system were more favourable than those offered in other branches of farming. Many non-co-operative marketing institutions have been set up in Wales during recent

[1] This *Journal* Vol. X. 1934.

years, more particularly in the field of dairying and these have been extending their activities over an ever widening circle. In the more fertile regions of the Principality factories have been in existence for some years and have rendered considerable services to farmers, but had they been established and maintained on co-operative lines the benefits obtainable by producers would have been still greater.

TABLE II.

Turnover of Marketing Societies.

Year.	*Dairy Produce.* £	*Eggs and Poultry.* £	*Other* £	*Total.* £
1933	32,698	30,151	8,364	71,513
1934	46,241	23,721	7,226	77,188
1935	81,632	26,342	9,316	117,290

Further developments in the factory manufacture of dairy products are likely in the future, although as yet it is not clear what direction the movement will take. Some new societies may be formed in undeveloped regions whilst the opening of separating stations by existing factories may in some cases be more advantageous. In the marketing field also some progress in the co-operative handling of eggs and poultry, potatoes and wool must be recorded. Although considerable developments have been made during the last three years in marketing some of the commodities produced on Welsh farms, the total quantities handled are not statistically recorded in the above tables as they do not all pass through the local co-operative societies. Many farmers now dispose of their wool supplies by joint effort, whilst small consignments of fat stock are often bulked together and dispatched to central abattoirs.

Some requisite societies also handle farm produce. During recent years the quantity of dairy produce passing through such societies has shown a rapid decline; this, however, is not a sign of failure but rather of a change in methods of business. It is doubtful whether the establishment of departments to deal with farm products as adjuncts to requisite societies is the best method of procedure. The processing, manufacture and sale of agricultural commodities are highly technical in character and can hardly be satisfactorily conducted as a sideline to other business. Before the advent of the Milk Marketing Scheme some societies acted as wholesalers of liquid milk, but now that type of business has been very largely discontinued.

TABLE III.

Produce Sales by Societies.

	1933.	*1934.*	*1935.*	*1933.*	*1934.*	*1935.*
	£	£	£	%	%	%
Dairy Produce	37,250	4,626	3,704	70.2	17.0	12.3
Eggs and Poultry .	11,828	21,899	25,258	27.9	80.3	83.7
Grain . .	37	--	82	0.1	—	0.3
Wool . . .	980	726	1,119	1.8	2.7	3.7
Total . . .	53,095	27,251	30,163	100.0	100.0	100.0

Requisite Societies.

Societies which deal exclusively in farmers' requirements continue to show appreciable progress. Development in this sphere cannot be measured in terms of the number of societies, as in general it has been found more desirable to allow existing societies to open depots in undeveloped districts than to establish new societies. Some societies have a large number whilst three or four depots are quite common. Considerable unnecessary expenditure is avoided in this way, especially in relation to office work. More favourable discounts on purchases are allowed to the societies as orders increase in bulk; transport costs per unit of goods are kept as low as possible and all undesirable competition between small societies is avoided. This tendency towards larger organisation, as a rule, provides for farmers the assistance of a sound society and one whose officers have had some experience of the work. This has proved to be a more desirable line of procedure than the establishment of new societies, as the latter may be financially weak for a number of years.

Turnover.

The cash turnover of the fifty-six requisite societies has shown a steady rise since 1933; there was an improvement of 10.1 per cent. in 1934 and a further advance of 9.8 per cent. in 1935. Some small setbacks, however, were quite inevitable during the years of the great depression. Farmers curtailed their purchases, especially of fertilisers, in face of falling prices, and in consequence the trade of co-operative societies may have suffered slightly. While the total cash sales per society does not provide a true or complete measure of the work they do or of the services they render, it is one of the clearest guides to general conditions.

There has been an increasing demand amongst farmers in recent years for ready-made livestock feed. The modern tendency on farms has been to curtail arable areas and this has meant an

appreciable fall in the available supplies of home grown feed. Before this change occurred farmers' requirements of artificial foods were largely determined by the type or quality of their own supplies, and they selected certain feedingstuffs for purchase very largely in order to enable them to prepare balanced rations. More recently, however, farmers have been in the habit of purchasing

TABLE IV.

Cash Turnover of Requisite Societies.

Year.	*Number of Societies.*	*Cash Turnover.*		*Total.*
		Requisites.	*Produce.*	
		£	£	£
1933	62	1,066,668	53,102	1,119,770
1934	61	1,205,662	27,252	1,232,914
1935	60	1,323,175	30,163	1,353,338

prepared rations for all classes of stock but in Wales more particularly for cows. When these rations consist of proprietary compounds on which there are heavy advertising or other selling costs the prices tend to be rather high. Some farmers' co-operative societies have now entered this field of supply with good results to themselves and to their members.

TABLE V.

Classified Sales (56 Societies*).

	1933.	*1934.*	*1935.*
	£	£	£
Feedingstuffs	595,315	677,179	738,428
Implements	10,250	16,277	12,424
Seeds	23,300	30,218	28,385
Fertilisers	16,968	46,672	59,299
Others	119,443	131,067	140,890
Total	795,276	901,413	979,426

* Societies for which complete information is available.

Feedingstuffs account for over 80 per cent. of the total sales of requisite societies. The movement towards increased production or sale of milk has been quite a conspicuous feature during recent years and the demand for purchased feed has advanced.

In some cases societies are developing as general stores at which farmers can be supplied with a considerable proportion of their requirements. Sales of small articles of miscellaneous character continue to rise, which indicates that the grocery, hardware and the general retail trade is expanding.

TABLE VI.

Turnover of Feedingstuffs and Fertilisers corrected for Changes in Prices.
(50 Societies).

	Feedingstuffs.		*Fertilisers.*	
	Index No. of Prices, 1911-13 = 100	*Corrected Total.*	*Index No. of Prices, 1911-13 = 100*	*Corrected Total.*
		£		£
1933	85	700,370	90	52,186
1934	91	744,152	90	51,837
1935	87	848,767	88	67,385

Prices of feedingstuffs remained fairly steady during the period under review although there were some seasonal movements; those of fertilisers, however, remained almost stationary. It is clear from the Table that the tonnage of feedingstuffs, as indicated by the figures of " corrected " sales, has moved steadily upwards. The rise for 1935 in fact was quite outstanding. The turnover of fertilisers has moved in an erratic way, quite a conspicuous rise occurred, however, in 1935. With the slight recovery of prices and improvement in the general situation, farmers were in a better position to devote attention to the cultivation of the land.

TABLE VII.

Estimated Percentage changes in volume sold over previous year.

Year.	*Feedingstuffs.*	*Fertilisers.*
	%	%
1933 ..	+ 6.6	— 10.5
1934 ...	+ 6.2	— 0.6
1935 ...	+ 11.0	+ 29.9

With the comparatively heavy quantities of artificial feed passing on to the holdings, many farmers claim that they need not incur such heavy expenditure on fertilisers: fertility is replenished to some extent by the manurial ingredients of the feedingstuffs used.

Profits.

The percentages of gross profits made by different societies continue to show considerable variation, but on the whole they have shown a tendency to rise. The wide scatter is partly due to differences in character of the businesses. Some societies deal in appreciable quantities of groceries and similar commodities which are handled in small lots and in general the margin or " mark up " on such commodities is somewhat wider than on goods which are sold in comparatively large consignments.

TABLE VIII.

Societies grouped by Gross Profits as Per cent. of Sales.

Gross Profits as per cent. of Sales.	*Number of Societies.*		
	1933.	*1934.*	*1935.*
Under 1	3	—	—
1— 2.9	1	1	2
3— 4.9	4	4	2
5— 6.9	8	9	7
7— 8.9	12	11	10
9—10.9	9	12	11
11—12.9	10	10	5
13—14.9	5	4	10
15—16.9	2	3	5
17 and over	2	2	4
Total	56	56	56

The net profits made in recent years have been well maintained and in many cases have increased. In view of the competition that now exists in the trade it is always necessary for societies to keep the prices they charge as low as possible, but at the same time, they must attempt to maintain their capital whilst some must strive to augment their reserves. It is the smaller societies that run the risks of suffering losses as on a comparatively small turnover the margin per unit of goods sold needs to be relatively high before satisfactory financial results can be shown. Societies which return very low net profits measured as a percentage of sales often show relatively high costs of operation.

TABLE IX.

Societies grouped by Net Profits as Per Cent. of Sales.

Net Profits as per cent. of Sales	*Number of Societies.*		
	1933.	*1934.*	*1935.*
Zero and below * ...	12	7	8
0—0.9 .	7	9	8
1—1.9 ..	12	15	9
2—2.9	10	10	8
3—3.9 . . .	8	5	3
4—4.9	3	2	11
5—5.9	1	4	6
6—6.9 . . .	2	3	—
7 and over . ..	1	1	3
Total	56	56	56

* Usually equal to losses.

In the case of co-operative societies there is no single satisfactory criterion of efficiency. The percentage net profits made should be considered in conjunction with the prices at which goods are sold and the maintenance or increase of capital, but these three factors cannot be expressed in a single figure. The Table below, however, indicates some of the factors that are of importance in management.

TABLE X.

Relations between Capital and Profits.

Net Profit as % of Sales.	*Borrowed Capital as % of Total Capital.*	*Borrowed Capital as % of Working Capital.*	*Debtors as % of Sales*	*Debtors as % of Working Capital.*
Zero and below	45.1	53.5	37.5	74.4
0—1.9	37.9	52.5	21.1	64.0
2—3.9	28.7	43.1	18.1	58.2
4—5.9	17.1	25.3	17.9	54.9
6 and over	15.0	19.4	17.4	50.9

Problems relating to capital and credit always deserve close attention as the ways in which the financial resources of societies are used are almost invariably reflected in business results. The extent to which societies make use of borrowed capital appears to be closely related to the profits made. Those which were unable to return any net profits borrowed almost half their capital whilst at the other extreme the high profit businesses owned over five-sixths of their capital.[2] Borrowing heavily has its disadvantages as interest charges have to be met irrespective of whether the business is able to show a profit. The capital resources of societies can be conveniently divided into two classes, viz., fixed and working capital. In some cases a considerable proportion of the total may be invested in permanent fixtures, with the result that borrowing may have to be resorted to, on a large scale, for supplies of working capital. Societies returning the lowest profits borrow over half of their requirements, whereas those showing better results are only dependent on outside sources for between a fifth and a quarter of their supplies of working capital.

Giving long credit to customers is a frequent source of trouble, nevertheless credit for a reasonable time must be given, otherwise

[2] It may be noted that a society may earn net profits in trading equal to 2 per cent. on total capital used, but paying 5 per cent. on half the capital which is borrowed may suffer loss.

farmers would hesitate to do business with the societies. There is almost invariably a correlation between the profits made and the amount of credit given; when a considerable proportion of the working capital is used up in this way a shortage for other purposes is often experienced and quite frequently borrowing must be resorted to in order to carry on the business. In effect, certain societies borrow money or take trade credit to provide in turn trade credit for farmers. In some cases over a third of the total sales made in a year remain unpaid for at the close. Normally credit for some two months is given, yet societies returning the highest net profits allow somewhat less. When considerable credit is given severe inroads are often made into the financial resources of a society and its freedom of working may be curtailed. The business success of societies is in fact closely related to the way in which working capital is used. Businesses unable to show profits are handicapped, especially in purchasing, as almost three-quarters of their working capital is used in giving credit to customers.

TABLE XI.

Some Measures of Efficiency.

Net Profit as % of Sales	*Total Trade Costs as % of Sales.*	*Salaries and Wages as % of Sales.*	*Salaries and Wages as % of Total Trade Costs.*	*Salaries and Wages as % of Working Capital.*
Zero and below	8.8	4.3	69.2	9.2
0—1.9	7.8	4.2	53.9	12.0
2—3.9 .	6.7	3.6	53.5	12.6
4—5.9 ..	8.1	4.0	49.7	13.6
6 and over	6.3	4.1	49.8	13.5
Average ...	7.7	4.0	55.1	12.2

Salaries and wages on the whole amount to over half the costs of running the businesses and the societies returning lowest net profits tend to show a relatively heavy outlay on labour. Sound organisation and economy in the use of labour are of supreme importance in all cases. A certain degree of specialisation of work is possible in the large businesses but employees of the smaller ones are generally expected to undertake many different kinds of work. Considerable time is often wasted in changing over from one task to another. High trade costs per ton of commodities handled may not be an indication of inefficiency for costs will vary with services rendered, and when

there is much delivery, or some processing, labour costs are increased. But a heavy outlay on labour in relation to other costs is often a sign of danger unless there are particular reasons for it. There appears to be a fairly close relationship between the net profits made, the expenditure on labour, and the amount of working capital used. Many farmers' co-operative societies in Wales need to modernise their methods of handling goods and to examine the possibility of installing machinery to do certain classes of work. It is too often found that human labour is employed to move goods within the stores; this work is done at much lower cost in others with the aid of a little machinery and in general the efficiency of working is higher in such cases.

On the whole the co-operative movement is showing definite progress; sales are increasing and the societies are well managed. In view of the existing competition to gain the farmers' patronage societies need to give as good services as can be obtained elsewhere. Farmers need guidance and advice, and the societies should be in a position to perform these services. Although achievements in this direction will not be amenable to measurement, they will form an important part of the benefits of the movement and must be included in the results finally attained. On measurable tests, however, the requisite societies of Wales have done quite well. They have had an appreciable effect upon the prices charged to farmers for their feedingstuffs and fertilisers, they have maintained the increase in turnover of previous years and have augmented their reserves of capital. They are now in a position to do much for farmers in the Principality. In some cases societies could strengthen their positions and assist their members by mixing or arranging for supplies of balanced rations. In others careful arrangements for supplies of suitable seeds and keen canvassing and advisory work for sales would lead to improvements in local farming. A movement which has run many risks, suffered and overcome many dangers, suffered some set-backs and made progress by strenuous efforts, tends at some stages to become conservative; but the time is coming when the capital resources and general condition of societies will warrant general movement towards progress.

THE PROFITABLENESS OF POULTRY ENTERPRISES IN WALES.

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During the ten years 1924 to 1934 there was an increase of 65 per cent. in the number of fowls recorded on Welsh holdings exceeding one acre, the numbers increasing from 96 to 163 per 100 acres of crops and grass. In England the density and the rate of increase are greater, but the general conditions of climate, topography and nearness to consuming markets are more favourable to the English farmer.

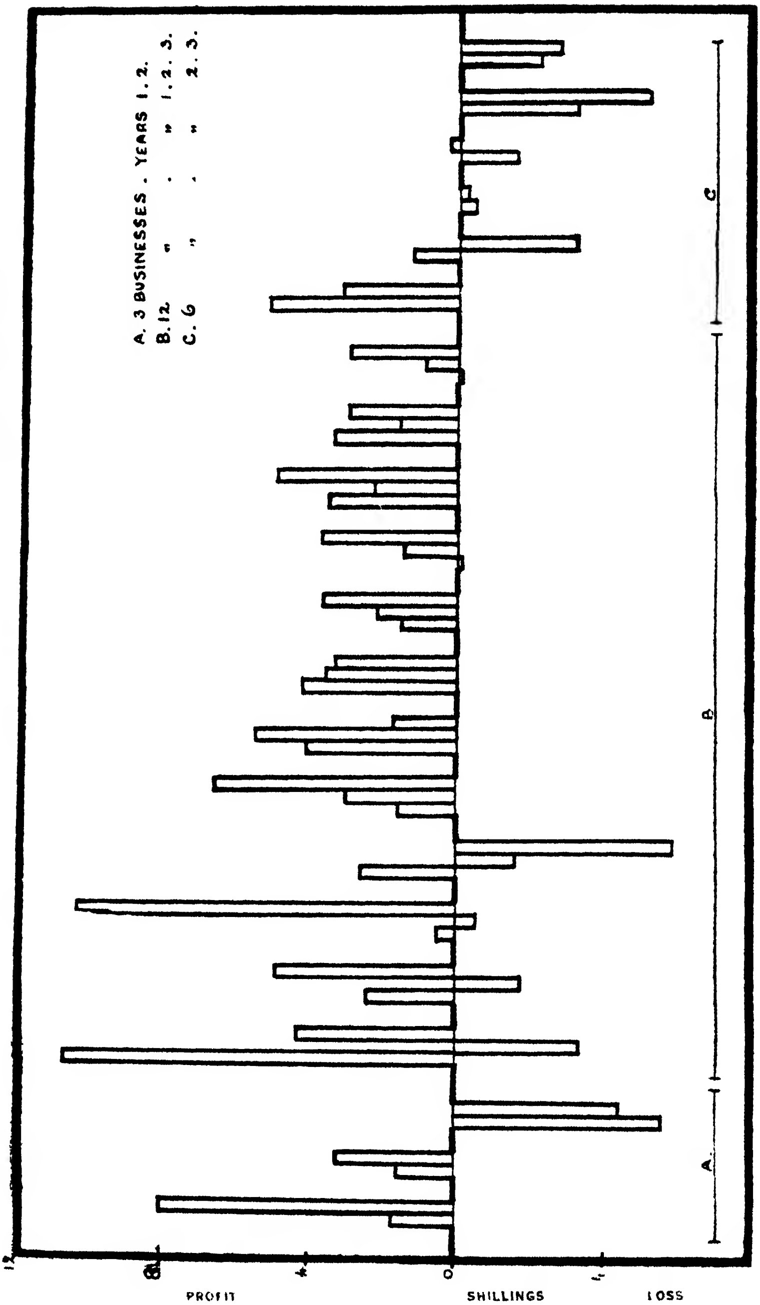
Poultry on general farms make the largest single contribution to the total home production. In Wales, poultry on such farms gave an average return of £32 6s. 0d. per farm or 4.1 per cent. of the total farm receipts in 1929-30 and by 1934-5 these had increased to £80 14s. 0d. or 7.8 per cent. of the total.

Until the present decade poultry were highly profitable when managed efficiently, but owing to the relatively greater decline in the prices of eggs than in the costs of poultry foods and to the increasing importance of poultry diseases, greater uncertainty has recently prevailed. A special study of Welsh poultry enterprises for the last three years gave the following results :—

	Number of Enterprises.		
	Profit.	*Loss.*	*Total.*
1933-4 ..	19	7	26
1934-5 ..	14	10	24
1935-6 .	33	6	39
Total ..	66	23	89

Of the total cases examined over the three years, about one quarter had losses, the largest proportion of losses being recorded in 1934-5, while 1935-6 was the most favourable year.

Continuous information available for twelve enterprises over the three years shows that six made profits in each year, five made profits in two and losses in one year, and the remaining enterprise realised a profit only in one year. In the chart below the importance of the profit or loss per bird in the laying flocks is shown for those enterprises where the data is available for more than one year.



FLUCTUATIONS IN THE PROFITS AND LOSSES PER BIRD.

The chart deals with thirty-seven cases of profit and seventéen cases of loss, and the following is a summary for each year.

		Profit. No.	*Loss.* No.	*Total.* No.
1933-4	....	12	3	15
1934-5	....	12	9	21
1935-6	....	13	5	18
Total	....	37	17	54

The enterprises can be placed into three main groups. Six enterprises with profits in each of the three years form one group, which is further characterised by relatively small fluctuations in the amount of profit per bird in the laying flock. This group exhibits the general conditions of good healthy flocks under the control of efficient and interested managers.

A second group shows marked inconsistency in the amount of the profit or loss per bird in each of the years. The extraordinarily wide fluctuations in the amount of the profit and loss shown by this group is almost entirely due to management. There are cases where the number of birds in the laying flocks vary considerably from year to year owing to the absence of a definite policy of hatching and rearing pullets each year for replacing the old hens which have died or been culled and sold. Where this happens the cost per bird of capital depreciation shows important variations from year to year. Further, there is evidence that in some cases sudden and important changes were frequently being made in kinds of foods fed to the laying flocks. A change to a cheaper ration may be justified in the Spring and early Summer months, when prices of eggs are low, but to make frequent changes in the Autumn and Winter months may have an important influence upon seasonal egg production.

Lastly there are indications of a group which have sustained important losses varying little in successive years. In this group we have the effect of sudden outbreaks of diseases which take time to overcome, especially in the case of specialist poultry enterprises.

Profits and Losses per Bird. Of the eighty-nine cases examined during the three years, forty-six had annual profits ranging up to 5s., and twenty had profits exceeding 5s. per bird in the laying flocks. In nineteen cases the annual loss amounted to less than 5s., and in the remaining four cases to more than 5s. per bird. The following summary gives a general picture of the financial positions of the enterprises in each of the three years.

Profit or Loss per Bird in the Laying Flocks.	*Number of Cases.*		
	1933-4. No.	*1934-5.* No.	*1935-6.* No.
Profit over 5s.	2	4	14
Profit under 5s.	17	10	19
Loss under 5s. . ..	5	9	5
Loss over 5s. . ..	2	1	1
Total	26	24	39

Although in the second year a larger proportion of the enterprises showed profits exceeding 5s. per bird, the profits in general tended to be lower than in the first year. In 1935-6 there was a substantial improvement with the bulk of the profits ranging from 4s. to 6s. per bird. In each year the total profits exceeded the total losses, there being a favourable overall balance of 1s. 11d. per bird in 1933-4, 1s. 6d. in 1934-5 and 4s. 9d. in 1935-6.

Profit and Loss per £1 of Total Costs. Statements relating to the profit and loss per bird do not always provide the most useful standards of comparison between groups of enterprises. Although all the enterprises examined here were almost wholly concerned with commercial egg production they did show wide differences in the relative importance of the laying flock to the total birds on the farm. When the records for a single enterprise are compared over a number of years the same differences may be found. Some farmers hatch and rear all the pullets required to maintain the size of laying flocks, others purchase day-old chicks, six week old pullets, and in some cases pullets which have nearly reached the productive stage. Even when it is the practice to hatch and rear all the pullets required to maintain the laying flock there will be differences in the crop of pullets and young cockerels as a consequence of a good or bad hatching season. In every case the costs other than those of egg production will vary, as also will the importance of the returns from the sales of young table birds, old hens and culled pullets. It is more important, therefore, to compare the value of the output per unit value of input. The following summary shows that there was a wide variation in the value of the output per £1 of cost.

In the first year the profit margin per £1 of net costs for the whole group was 2s. 2d. Nearly half of the enterprises had profits ranging up to 4s., and four had profits exceeding that amount. There was only one case where the loss amounted to

Range of Net Returns per £1 of Net Cost.	*Net Returns per £1 of Cost. Number of Cases.*		
	1933-4.	*1934-5.*	*1935-6.*
28/- and over	3	1	12
26/- and under 28/- .	1	4	5
24/- and under 26/-	4	2	9
22/- and under 24/-	6	5	4
20/- and under 22/- . ..	5	2	3
18/- and under 20/-	4	6	3
16/- and under 18/-	2	3	—
Under 16/-	1	1	3
Total	26	24	39

more than 4s. per £1 of net cost. In 1934-5 there was some improvement in the positions of those enterprises making profits, while the magnitude of the losses was of the same order as in the previous year. Owing to the larger number of enterprises with losses in the second year the over-all profit per £1 of net cost was only 1s. 9d. There was a general improvement in the profits earned in the last year, and of the thirty-three enterprises with profits twenty-six had profits of 4s. or more per £1 of net cost, while seventeen had profits of 6s. or more. Over the whole group for that year the profit amounted to 5s. 3d. per £1 of net cost.

Profits, Losses and Feed Input. Expenditures on foods represent 60 to 70 per cent. of the total net cost of producing eggs and poultry. Individual enterprises, however, show considerable variations in the cost of foods per bird in the laying flock. For enterprises mainly associated with egg production the chief variations in the cost of foods, per bird, are due to differences in the ration fed. The following summary shows that where mashes

Mashes and Meals as a Percentage of Total Foods Purchased.

	Over 50 per cent.		*Under 50 per cent.*	
	Mash.	*Price. per cwt.*	*Mash.*	*Price. per cwt.*
	%	s. d.	%	s. d.
1933-4	60.2	8 5	45.3	7 8
1934-5 .. .	66.1	8 6	44.1	8 0
1935-6	66.2	8 4	36.0	7 8
All years	60.1	8 4	40.1	7 8

and meals represented over 50 per cent. of the total quantity of foods purchased the average price was from 6d. to 8d. per cwt.

more than for those cases where mashes and meals formed less than 50 per cent. of total foods.

The advantage to be obtained from feeding the more expensive rations is dependent upon the quality of the flocks. All flocks tend to give higher egg yields when fed on well balanced rations, but there are cases where the increased output does not compensate for the higher costs. Of the total cases examined during the last three years there are sixty-three for which detailed information of foods purchased is available. The evidence in its simple form is somewhat conflicting as regards relationships between the use of higher priced feeds and both output and profits.

In thirty-one cases mashes and meals formed more than 50 per cent. and in the remaining thirty-two cases less than 50 per cent. of the total quantity of foods purchased. In the former group there was a profit balance of 4s. 11d. on every £1 of total cost as compared with a balance of 4s. 5d. for the latter group. The number of cases for individual years is too small to make detailed comparisons, but it may be worth noting that in 1933-4 and 1935-6 the profits were highest per £1 of total cost for that group of flocks consuming the smaller proportion of mashes.

For the thirty-one cases in which mashes and meals formed more than 50 per cent. of total foods purchased the average output amounted to £2 1s. 7d. for every £1 worth of food consumed, and this was 8s. higher than that obtained by the other group. In 1935-6, however, the value of the output was greatest for that group receiving the smaller proportion of mashes and meals.

In all cases where profits were made there was a very close relationship between the profit balance per £1 of total cost and the value of the output per £1 of food consumed. The following Table (top of next page) shows that out of sixty-six cases of profits there were forty-one in which the balance amounted to 4s. or more on every £1 of total cost, and of this number only nine had an output per £1 of food consumed of less than £2.

Where losses occurred there was not the same close relationship between the value of the output for every £1 worth of poultry foods consumed and the value of the output for every £1 of total cost. In one or two cases the value of the output for every £1 worth of food consumed was exceptionally high, and yet heavy losses were made. Taking together all the cases in which losses were made, however, the average value of the output was only £1 12s. 4d. for the three years, or nearly 9s. less

Relation between the Value of the Output per £1 of Food Consumed and the Profit per £1 of Total Cost.

Profit or Loss per £1 of Total Cost.	*Value of Output per £1 of Food consumed.* 50/- & over.	40/- & under 50/-.	30/- & under 40/-.	20/- & under 30/-.	*Total Cases.*
Profit.					
10/- and over	8	1	—	—	9
8/- and under 10/- ...	1	6	—	—	7
6/- and under 8/- ..	—	8	2	—	10
4/- and under 6/- .	1	7	7	—	15
2/- and under 4/- ...	—	4	11	—	15
Under 2/- .	—	1	7	2	10
Loss.					
Under 2/-	1	1	9	2	13
2/- and under 4/- .	—	2	1	2	5
4/- and over	—	1	4	—	5
Total Cases	11	31	41	6	89

than that for all the cases in which profits were shown. The following is a summary of the value of the output for each of the three years.

Value of the Output per £1 of Total Cost and per £1 of Food Consumed.

	Cases in which Profits were made. Output per £1 of total cost.	*Cases in which Profits were made.* Output per £1 of Cost of Food.	*Cases in which Losses were made.* Output per £1 of total cost.	*Cases in which Losses were made.* Output per £1 of Cost of Food.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1933-4 ..	1 3 11	2 0 4	0 17 6	1 14 11
1934-5	1 3 8	2 2 3	0 18 1	1 12 1
1935-6 ...	1 6 2	2 2 2	0 16 4	1 12 11
All years	1 4 10	2 1 0	0 17 3	1 12 4

These groups show only small variations during the three years in the amount of the output for every £1 worth of food consumed. The difference between the amounts for each group in any single year varied from 5s. 5d. in 1933-4 to 10s. 2d. in the following year.

The average cost of foods for every 120 eggs produced during the three years by those flocks making profits amounted to

7s. 8d., or just over nine pence per dozen eggs, as compared with 9s. 11d. per 120 eggs and nearly one shilling per dozen eggs for flocks making losses. It is significant that the average loss per 120 eggs produced approximates to the difference in costs of food for the two groups.

Profits, Losses and Egg Yields. In general the egg yields per bird were good. During the three years there were only fourteen cases in which the average yield was less than 120 eggs while there were fifty-seven cases where the flock average amounted to 130 or more. In thirty instances the yield exceeded 160 eggs per bird. The following summary shows the general range of egg yields in each of the three years.

Average Egg Yields.

Range.	*Number of Cases.*		
	1933-4.	*1934-5.*	*1935-6.*
160 eggs and over	6	6	10
130 and under 160 eggs .	13	7	16
Under 130	7	11	13
Total . ..	26	24	39

The records show that in all the cases where losses were made the annual average yield during the three years was 128 eggs as compared with 143 eggs for those in which profits were made. In the majority of cases, however, the low egg yields given by flocks making losses were due to unhealthy stock. With healthy flocks profits may be associated with either high or low yields according to other circumstances. There were some individual cases of losses being made with healthy flocks giving very high yields, while in a number of cases in which the flocks gave relatively low yields very favourable profits were made.

During the three years there were fifteen comparable cases in which the yield was 160 eggs or more per bird in the flocks and twenty-nine cases where the yield was less than 130 eggs. The former group showed an average profit for the three years of 3s. 10d. for every £1 of cost as compared with ten pence for the latter group, but the eggs from the flocks with the higher yields commanded the higher prices. The returns from the sale and consumption of eggs amounted to 12s. 4d. per 120 eggs produced for the group with high yields, and to 11s. 9d. for the group with

low yields. The average net costs of producing eggs for the two groups were as follows :—

Costs of Egg Production in Relation to Egg Yields.

	High Yields.	*Low Yields.*
Average yields	168	116
	pence	pence
Total Gross Cost per dozen eggs ...	16.7	17.8
Deduct returns other than from eggs	4.8	4.4
Net Costs	11.9	13.4
Average Price of Market eggs . .	14.4	13.9
Margin	2.5	0.5

These results show the financial advantages of possessing flocks which give moderately high yields. The records do not lend themselves to a precise statement of the cost per dozen eggs for each individual production factor, but it is clear that where reasonably high yields are obtained the cost of foods and labour per 120 eggs is appreciably lower than for those cases where very low yields are obtained.

In addition to the cheaper costs of production for those flocks giving the better yields it is generally the case that individual birds giving the higher annual yields produce a larger proportion of their annual total during those months when prices are at the higher levels. The yearly average price received per dozen eggs sold from such birds would, therefore, be higher than that for eggs sold from birds giving very low yields. Further, owners of the better flocks are able to dispose of a large proportion of the eggs produced in the spring to people requiring hatching eggs.

Profits, Losses and Death-Rates. In most cases the heavy losses sustained were the direct result of high mortality rates. It is now well established that a large percentage of the deaths amongst poultry are directly associated with conditions of egg production. Further, there has been a general tendency to breed for high egg production at the expense of stamina. Managers have been encouraged to feed for high yields. Undue forcing reduces the vitality of flocks and they become easy prey to diseases. Flocks on specialist farms require particular care and attention if deaths are to be minimised. The area of land on which such flocks are kept is limited and in a number of cases the land is stocked to its utmost capacity. When disease breaks out on such holdings no fresh land is available and even when the flocks are reduced to a minimum a number of years may pass

before the flocks and the land have been completely rid of the causes of deaths. Under such conditions the land, buildings, and equipment may not be used to capacity for a number of years, with the result that the charge for rent and capital depreciation will be a heavy burden on the laying flocks.

Profits, Losses and Prices of Eggs. The erratic fluctuations in the occurrence of the profits and losses shown for individual enterprises over the three years cannot be associated with changes in the market prices for eggs. In 1933 and 1934 there was some decline in prices as compared with previous years, but during the summer and early autumn of 1935 the seasonal upward movement in prices continued to a higher level than in the previous two years while throughout 1936 prices have been generally higher. The changes, however, are much smaller than the fluctuations in the margin of returns over costs.

Continuous records over the three years are available for twelve enterprises. These show that the yearly average price received for market eggs in 1935-6 was 2½d. per dozen higher than in 1933-4 and 1½d. higher than in 1934-5. This improvement was better than that shown for all the cases which showed an increase of 1d. per dozen in the last year with prices approximately the same, namely, 1s. 2d. per dozen, in the former two years. Some of the increase shown for the twelve enterprises was due to changes which occurred in methods of selling eggs. A number of farmers who had previously been in the habit of selling all their eggs to higglers and dealers are now selling to grading stations, and have obtained some financial advantage from selling on a graded basis.

The annual average prices received by individual farmers in any year show considerable fluctuations, and are largely the result of different methods of marketing. Where the farmers are dependent upon higglers and dealers for the disposal of their eggs, especially if the final consuming markets are situated long distances from the points of production, the average price is relatively low. As the amount of the marketing service performed by the farmers increases higher average prices are obtained, and when the producers are able to dispose of their eggs direct to the consumer the average price obtained will be highest.

There were cases where losses were made despite the higher average prices realised, and in one or two cases the extra cost of retailing eggs to consumers or conveying them long distances to retailers was not compensated by the better prices realised.

Profits, Losses and Farm Income from Poultry. The average profit per farm amounted to £27 13s. 5d. in 1933-4, to £16 2s. 1d. in 1934-5, and to £55 13s. 2d. in 1935-6. From the following summary it will be seen that in the latter two years the average net returns and net costs were lower than in the first year.

Net Returns, Costs and Profit per Farm.[1]

	1933-4.	1934-5.	1935-6.
Average Size of Laying Flocks.	282	217	209
	£ s. d.	£ s. d.	£ s. d.
Net Returns . .	279 13 10	202 2 2	268 10 5
Net Costs ..	252 0 5	186 0 1	212 17 3
Profit	27 13 5	16 2 1	55 13 2
Charge made for unpaid labour .	39 1 8	32 0 1	34 8 9
Total income per flock	66 15 1	48 2 2	90 1 11

In part these reductions in total costs and returns were due to a smaller average laying flock, for example, the average size in 1934-5 was only 77 per cent. and that for 1935-6 74 per cent. of the average size in the first year. Returns from the sale, consumption and use of eggs on the farms were lower by more than £58 per farm in the second as compared with the first year, but in the last year the difference was just over £25. The average returns received by sales of poultry were not more than one-third of the total in any year.

The smaller total net costs per farm recorded for the last two years was due almost entirely to reductions in the costs of foods. In 1934-5 they were nearly £40 lower than in the first year and in the last year they were lower by £21. For flocks of so small an average size the cost of labour would seem to be high. In the first year the average cost of all labour amounted to just over £53 per farm, but it was eleven and ten pounds lower respectively in the following two years. It is claimed that one adult male person can operate a unit of 1,000 laying birds. Even on the assumption that the manager received a weekly wage of £3 the annual cost of labour would amount to only £156 per 1,000 laying birds or £39 per 250 laying birds.

Despite the unfavourable prices realised for eggs during the first two years and the increasing losses by deaths, the average

[1] In all these cases the profits and incomes are shown "sinking the losses."

profits obtained must be considered as favourable. In the first year the average profit was equal to a return of 11.8 per cent., that for the second amounted to 9.2 per cent., while in the last year it was as much as 24.8 per cent. on the annual average capital invested.

The total gross income which the farmers and their families received, and which had to cover unpaid manual labour, and interest on capital and management amounted, on an average, to nearly £67 per farm in 1933-4. In the following year it had declined by more than £18, but the general improvement in the last year resulted in an income amounting to over £90 being obtained. The records of the twelve enterprises for which information is available in each of the three years gave similar average results, while in this group there were cases in which exceptionally heavy losses by deaths had been sustained.

Conclusions.

The generol conclusions which emerge from this study may be stated briefly. The most important factors which affect the profitableness of the poultry industry to-day are the quality of the livestock and their management. All the major difficulties can be finally associated with inefficient stock or management. Disease and deaths are enormously important factors affecting the financial position of poultry enterprises, but careful control over the flock, over purchases of fresh stock, and over the land occupied will do much to reduce this item of cost.

There is increasing need for more intimate study of individual birds so that unproductive and unhealthy birds may be detected and removed. Associated with this is the need for greater knowledge of selecting, mating and general treatment of breeding stock in order to reduce the wastage of infertile eggs and the hatching out of unhealthy chicks. The study shows that some managers were far from reaching success in the operation of incubators and management of chicks during the early stages of their life. With foresight and careful management a sufficient supply of fresh pullets should be available to allow the necessary culling each year without any decline in the size of the laying flocks.

Although the situations of poultry farms vary to some extent as to the relative advantages and disadvantages which they offer to operators, the largest factors in success are those of determination of policy and day by day management. Policy must be determined to some extent by the situation of the farm, and

by any other interests which the manager may hold. The details of day to day management will depend to a large extent upon the policy adopted, but with any given policy different standards of management will be found. There are cases where failure to find a more favourable market for eggs has meant continuously low profits and even small losses over the period, but it may be expected that the general extension of the practice of selling directly to packing stations will have the effect of narrowing the range of prices within particular districts. The annual average price is affected by the method of marketing and also by the seasonality in production. Even within the short period covered by these records there is evidence of a general levelling of the abnormally wide seasonal variations which were found on general farms. The smaller type of incubator is in common use and there is keenness to secure early pullets for the laying flocks, the bulk of them commencing to lay before the beginning of October. There were, however, cases in which average monthly production during the winter was as low as 2 to 4 per cent. with the result that low annual average prices were obtained.

Seasonality in production may be intensified by bad feeding and housing accommodation. The records show that the majority of farmers feed balanced rations, but in some cases grain forms the bulk of the food fed. In nearly every case lower egg yields were obtained from flocks consuming rations consisting mainly of grain. There is a general desire on the part of managers to provide their poultry with properly built and equipped housing and even on the general farms specially built houses are being preferred to the old practice of accommodating the birds in the general farm buildings.

THE PRESERVATION OF GREEN FODDER.

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and

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The difficulty frequently experienced in harvesting the hay crop in good condition in Wales is mainly due to climatic conditions; this is particularly true in the case of upland farms and consequently any other method which reduces the risk of loss in harvesting cannot but be of interest and importance to our farmers.

As early as 1848 we find attempts made to overcome this difficulty by converting green succulent crops into silage, and in the early eighties, owing to a succession of wet seasons, interest was again stimulated in the process, when a considerable amount of grass was preserved by this method.

Further impetus was given to the making of silage by Sir Massey Lopes, who in the year of his presidentship of the Royal Society of England, offered a prize of 100 guineas " For the best Silo in England and Wales in actual work during the winter of 1885-86." The Society at the same time offered a prize of £25 " For the best stack, or other system for obtaining silage without a silo in England and Wales in actual work during the winter of 1885-1886."(1).

For the President's prize thirty-seven competitors entered, one of whom was from Wales, the late Mr. W. A. Darbishire, Nantlle, Penygroes, R.S.O., Caernarvonshire. It is of interest to note the material that Mr. Darbishire made into silage. First the produce of half an acre of chaffed green oats was placed in the silo, then that of two acres of meadow grass, and after an interval of several days the produce of two acres of lucerne and finally a crop of meadow grass --in all the produce of about twelve acres.

In the report of the judges one reads that " the silage was found to be excellent and of uniform quality " and that " the cattle were fond of it."

The introduction of the cylindrical stave silo into Britain from America in 1901 revived interest in the study and making of silage. As a result of modern work, it has been shown that under certain conditions ensilage is in many ways superior to hay making, for the losses during the making and storing of hay are often very high(2). Thus the average loss of dry matter in the process has been estimated at 25 per cent.—representing a monetary loss to the country of about five and a half million pounds per annum(3), while in very bad weather much larger losses are experienced. It has also to be remembered that hay made under ideal conditions is essentially a roughage, and in the main fulfils the maintenance requirements of stock, whereas in the modern processes of silage making, the aim is to conserve young grass, a material that is greatly superior in nutritive value to grass at a later stage of growth. Many investigations have shown that by careful management grassland can be made to yield a product containing 20 per cent. of crude protein in its dry matter, which if converted into good silage would supply

the stockman with a foodstuff far superior in feeding value to the hay that would subsequently be made from it.

The problem of converting herbage rich in protein into good silage is therefore an important one, and is receiving attention in most European countries. In many, special crops are grown for the purpose, but in Wales grass and mixtures of grasses and clovers are the most obvious and convenient material available.

Silage made by any of the older methods whether in a clamp, pit, stack, or specially constructed silo suffered considerable loss in nutritive value owing to fermentation and the accompanying rise in temperature. In this connection control of the air supply is of primary importance, for it is by exclusion of air to the mass of fodder that losses of nutrients due to chemical changes brought about by fermentation are reduced to a minimum.

The control of the air supply is influenced by the extent of compression to which the material ensiled is subjected, and this is largely dependent upon the maturity of the material. If too mature, compression is often difficult and inadequate, and although the silage produced is sweet and palatable, the loss of nutrients is high. On the other hand, if the material is too succulent and the exclusion of air too complete the product will be sour.

During ensilage a number of important chemical changes take place, all of which result in loss of nutritive value. Thus for some time after cutting the plant cells still live and respire, the carbohydrates being broken down into carbon dioxide gas and water, and as oxygen is necessary for respiration limitation of the air supply is essential to prevent excessive loss of carbohydrates. Plant cells also contain enzymes which break down proteins into simpler compounds called amides, and at the same time when the supply of air is limited carbohydrates are decomposed by the agency of bacteria into organic acids such as lactic, butyric and acetic acids. The production of lactic acid is of the greatest importance in the making of good silage, for the acidity developed in this way checks the less desirable fermentations such as those giving rise to butyric acid. To estimate the loss of dry matter in making silage under average conditions is impossible for this will naturally vary within wide limits depending on a variety of circumstances.

As a result of investigations carried out in Finland by Professor Artturi I. Virtanen, the fermentation and heat formation accompanying the making of silage have been greatly reduced by spraying the fodder ensiled with mineral acid solutions during

the process of filling the silo. These acids consist mainly of sulphuric and hydrochloric acids and are added with the object of increasing the acidity of the mass to such a point that undesirable fermentations cannot take place (to a degree of acidity of pH 3 to 4).

Virtanen's method was put into general practice in Finland in 1928, and its success in that country may be gauged by the fact that it has been adopted by as many as 10,000 Finnish farmers.

In the year 1932 a preliminary investigation into the best methods of preserving grass and mixtures of grasses and clovers as silage was carried out at the College Farm, Nantcellan. This work was continued in 1933 and 1934, with the result that a considerable amount of data has been obtained on different methods of making silage.

In 1932 two types of silage were made, one by the ordinary pit method and the other in accordance with the process followed in Finland. For the purpose, three acres of aftermath were reserved which unavoidably became over-mature, with the result that much of the red clover, which made up some 80 per cent. of the herbage, had run to seed and was very stemmy.

The ordinary silage was made in a pit 30 inches deep and 14 feet wide dug on sloping ground in which the fresh fodder was evenly spread. The fodder ensiled was tightly packed by treading and drawing the carts over the clamp in the process of filling. When a height of about three feet was reached an interval of twenty-four hours was allowed to elapse in order that fermentation might begin before the air from the heap was excluded by the treading and pressure of the carting over the clamp. The filling was then continued and when completed the herbage was covered with sacking and a thick layer of soil.

The fodder preserved by the Finnish method and known as A.I.V. silage was made in a cylindrical wooden structure five feet nine inches in height with a diameter of ten feet. This was made of creosoted staves bound together with iron hoops and was sunk in the ground to a depth of one foot six inches. Around its base the excavated earth was banked and compressed to exclude air as far as possible, but provision was made for drainage of liquor from the silo. An over-silo similar in construction to the under-silo was fitted to the latter for convenience in filling. The principle underlying the A.I.V. method of making silage has already been referred to, and the spraying of the fodder with the acid was carried out continuously throughout the process of filling the silos. When this was completed, a special anti-mould

preparation was sprayed on the surface prior to its being sealed off with soil. The effect of the fodder being over-mature was that in spite of all precautions taken in the packing and filling of the silos, exclusion of air was not as effective as desired. This was made evident when the silos were opened, for the decomposition generally met with around the edge had penetrated deeper into the mass than usual and more so in the case of the ordinary than the A.I.V. silage, a result that cannot be accounted for wholly by the effect of the mineral acid added in the latter case, for the exclusion of air was naturally more effective where the material was ensiled in a wooden silo than in a pit silo.

Samples of the fodder were taken for chemical examination both at the time of filling the silos and later when the material was being fed to the stock. The samples were taken from the outer portion that had undergone the greatest amount of decomposition, and from the inner portion which had a more pleasant odour as well as better colour. The latter formed the greater part of the whole.

Table I gives the chemical composition of the green fodder and the average composition of the two types of silage made from it, the latter representing the material taken from the more central portion of each silo.

TABLE I (1932).

	Green Fodder.	*Pit Silage (Ordinary).*	*A.I.V. Silage.*
	%	%	%
Water ...	69.56	81.26	75.36
Dry matter	30.44	18.74	24.64
	Based on	dry matter.	
Ether extract	4.38	5.75	4.37
Crude protein ..	17.37	16.45	16.83
True protein ..	16.06	13.41	13.81
*Digestible protein	10.56	5.64	8.69
Fibre	25.22	34.78	29.14
Ash	7.34	9.15	8.45
Soluble Carbohydrates	45.69	38.87	41.21
Phosphoric Acid (P_2O_5)	0.68	0.63	0.60
Lime (CaO)	2.44	2.75	2.41

* Determined throughout the investigation by Wedemeyer's modification of Stutzer's "in-vitro" method.

The results clearly show that considerable losses were incurred in both methods of preservation, but that the chemical changes giving rise to these were greater in the ordinary than in the A.I.V. method. Thus a comparison of their respective dry matter, ether extract, digestible protein, fibre and carbohydrate content all favour the A.I.V. method of preservation. The

increase in ether extract that has occurred during ensilage is due to the formation of ether soluble substances such as organic acids from carbohydrates, and the extent of this increase indicates the amount of decomposition and indirectly the relative efficiency of the two methods. The percentage of crude fibre and ash is also higher in the ensiled material owing to the fact that there has been a considerable loss in carbohydrates both by oxidation and drainage resulting in a concentration of the other constituents. Further, these increases in ether extract, fibre and ash are seen to be greater in the pit silage and clearly show that the chemical changes which lead to the disappearance of the more soluble material proceed to a further extent where facilities for limiting the supply of air and compression are less adequate. The extent of the decomposition undergone by the material around the edge of the two silos compared with the centre is shown in Table II, where the average percentage composition of samples taken from both positions in each silo is given as well as that of the green fodder from which they were prepared.

TABLE II (1932).

	Green Fodder.	*Ordinary Silage (Pit).*		*A.I.V. Silage.*	
		Edge.	*Centre.*	*Edge.*	*Centre.*
Dry matter	30.44	14.24	18.74	22.32	21.64
		Based on	dry matter.		
Ether extract	4.38	1.82	5.75	2.94	4.37
Crude protein	17.37	25.12	16.45	19.74	16.83
True protein	16.06	23.88	13.41	18.39	13.84
Digestible protein	10.56	2.48	5.64	4.68	8.69
Fibre	25.22	30.62	34.78	29.97	29.14
Ash	7.34	13.98	9.15	10.27	8.45
Soluble Carbohydrates	45.69	28.46	33.87	37.08	41.21
Phosphoric Acid (P_2O_5)	0.68	1.08	0.63	0.91	0.50
Lime (CaO)	2.44	3.47	2.75	3.21	2.16

The difference in the percentage of digestible protein and carbohydrates in the silage from the edge and the centre of each silo is very striking, and to a large extent indicates the deleterious effect access of air has on the nutritive value of the material.

Calculations based on weights of green fodder used and silage produced from it, together with the dry matter figures for both, show that the loss of dry matter in the case of the A.I.V. silage was 14.5 per cent. and that this was much heavier in pit silage. An indication of these losses is obtained from the fact that with

equal quantities of green fodder ensiled, A.I.V. silage provided a supply of food which lasted twenty head of store cattle thirty days, whereas the pit silage only provided a similar ration for nineteen days. This difference was mainly due to the greater waste that took place around the edge of the pit silage in spite of all precautions in its consolidation.

The stock consumed the whole of the A.I.V. silage with the exception of some 2.5 per cent., and though the wastage in feeding the pit silage was greater, that portion of it that was consumed appeared more palatable to the cattle than the A.I.V. fodder. It should be mentioned that in the case of the latter a little lime was added to the concentrated food during the period that it was fed as a precaution against any ill effects due to its acidity.

In 1933, an area of grassland was selected and set aside to provide grass for preservation as silage. This area was divided into five plots of approximately two acres, and the produce made into ordinary, A.I.V., molasses and Defu silage. The fifth plot was allowed to run to hay and preserved in this form. The grass was cut on the 16th of June and ensiled the same day, the hay was cut on the 1st of July and harvested on the 4th of the same month. The A.I.V. silage was prepared in precisely the same manner as that of 1932, but in 1933 the ordinary silage was made in a wooden silo and not as in the previous year in a pit. The method followed in making molasses and Defu silage differed only from that made use of in the A.I.V. method in the solutions sprayed on the fodder when filling the silos. For the molasses silage the solution was one of treacle and water, 100 lb. of treacle being made up to forty gallons with water and sprayed on the grass at the rate of one gallon per cwt. of grass, the object of the addition of molasses being to provide material easily fermented to form lactic acid. For the Defu process the solution contained phosphoric acid, a higher percentage of sulphuric acid and a lower percentage of hydrochloric acid than in the A.I.V. process, and in addition a half per cent. of treacle. The amount of Defu solution added was such as to produce the required acidity which in this case corresponded to a pH of 4 to 4.5.

Samples of the green fodder were taken for chemical examination from each load as the silos were filled. These were intimately mixed to form as representative a sample as possible of the material preserved. Samples for the same purpose were taken when the silos were opened, and each of these was separated into two portions representing that met with at the edge and centre of the silo.

Table III gives the percentage chemical composition of the grass as well as of the four types of silage made from it in 1933, the latter representing the material taken from the more central portion of each silo.

TABLE III (1933).

	Grass.	*Ordinary Silage*	*A.I.V. Silage*	*Molasses Silage*	*Defu Silage*
Water	68.2	75.7	70.7	71.6	68.9
Dry matter	31.8	24.3	29.3	28.4	31.1
		Based on	dry matter.		
Ether extract	4.32	3.60	3.34	3.75	3.00
Crude protein	10.55	11.90	11.70	12.33	12.90
True protein	8.73	9.40	9.10	10.50	11.60
Digestible protein	7.75	7.30	7.50	5.70	6.72
Fibre	29.60	32.20	30.70	28.70	30.10
Ash	6.04	6.90	7.23	8.14	8.00
Soluble carbo-hydrates ...	49.49	45.40	47.03	47.10	46.00
Phosphoric Acid (P_2O_5)	0.52	0.66	0.50	0.50	0.57
Lime (CaO) . .	0.71	1.16	0.91	1.07	0.81

The fodder ensiled in 1933 was better suited for the purpose than that of the previous year, for being less mature it was more easily and effectively packed in the silos. Ample evidence of this is afforded by a comparison of the results in Tables I and III, where it is seen that the nutritive value of the original fodder in 1933 did not suffer to the same extent in the A.I.V. method of preservation as in 1932.

Indeed, Table III shows no very striking difference in the constituents determined in the dry matter of the four silages, nor is the difference in composition of the dry matter of any of the four silages and the grass ensiled very great. Thus the digestible protein in the dry matter of the ordinary and A.I.V. silage differs but little from that of the grass. Again, the fibre in the majority of the products is but slightly higher than that in the grass, and in this connection it is of interest to note that Woodman and his colleagues in their work on the digestibility of fibre found that this constituent is more digestible in silage than in the material ensiled (4), a finding that is of the highest significance when the percentage of fibre in silage is taken into consideration. The results in 1933, as in the previous year, show that the greatest loss of dry matter takes place in the ordinary method of preservation though this is not so great in a wooden silo as in a pit (Compare Tables I and III). The weight of green

material placed in each silo as well as that of the silage taken out was recorded in 1933. These stated on a dry matter basis together with the percentage loss of dry matter are given in Table IV.

TABLE IV.

Kind of Silage.	*Weight of dry matter.*		
	Put in Silo. *lb.*	*Removed from Silo.* *lb.*	*Percentage loss.* *lb.*
Molasses	981	889	9.4
Defu	1149	1039	9.6
A.I.V.	1354	1144	15.5
Ordinary	1103	784	28.9

The above results were calculated from the total weight of fodder placed in and removed from the silos, but from the latter the weight of decomposed material, *i.e.*, the portion unsuited for feeding purposes was deducted.

From Table IV it is seen that the loss of dry matter is not excessive. apart from that suffered in the ordinary method of preservation. In the A.I.V. process it is also higher than is claimed by the Finnish workers (5) though in general agreement with that found at other centres in Britain. The molasses and Defu silage show a relatively small loss and indicate that grass can be successfully conserved by these methods.

The silage around the edge was chemically examined as in the previous year, and a comparison of the results showed that similar changes had taken place each year. In 1933, however, the changes had not proceeded to the same extent, and this was no doubt due to the fact that the fodder preserved in 1933 was more suitable for the purpose.

Of the four processes adopted in 1933 for the preservation of grass, the molasses method was found to be the most successful and convenient and to produce the most palatable material. Consequently, in 1934 three silos were filled with grass cut at different stages of maturity and preserved by this means. The first was filled on the 18th of May with immature grass in a rain-soaked state, the second on the 30th of May with grass at a later stage of growth, though still immature, and the third on the 19th of July with fairly mature grass.

The chemical composition of the herbage and the silage made from it in each case is given in Table V.

TABLE V (1934).

	Sample 1. Very Immature Grass Rain Soaked.		*Sample 2. Immature Grass.*		*Sample 3. Fairly Mature Grass.*	
	Grass.	*Silage.*	*Grass.*	*Silage.*	*Grass.*	*Silage.*
Water	87.6	84.1	81.6	83.3	74.5	82.3
Dry matter	12.4	15.9	18.4	16.7	25 5	17.7
	Based on dry matter					
Ether Extract	6.43	10.45	5.13	8.35	4.27	5.34
Crude Protein	22.03	12.39	16.63	14.64	15.27	15.29
True Protein	14.80	9.83	10.34	8.50	9.51	14.43
Digestible Protein	19.40	4.11	14.24	10.17	12.70	6.09
Crude Fibre	24.20	36.00	26.90	30 00	28.60	33.00
Ash	9.73	10.76	9.07	11.29	9.11	9.07
Soluble Carbohydrates	37.61	30.40	42.27	35.72	42.75	37.30
Phosphoric Acid (P_2O_5)	0.90	0.46	0.96	0.68	0.60	0.48
Lime (CaO)	0.69	0.80	0.69	1.03	1.03	1.31

A comparison of the three types of grass ensiled gives an indication of their respective maturity, but the most mature of these was younger than the grass made into silage in 1933 (see Table III).

From the silo in which the immature grass containing but 12.4 per cent. of dry matter was ensiled, a considerable amount of liquor drained away which gave rise to an evil smelling effluent. This naturally resulted in an excessive loss of dry matter, but owing to inadequate facilities for its collection it was not possible to procure samples of the liquid for analysis. The silage produced was sour and smelt strongly of butyric acid, and the decomposition products of the proteins gave to the whole a particularly offensive smell. That a great deal of the protein was lost is seen from the large difference in the percentage of crude and true protein in the grass compared with the silage made from it. Such differences are much smaller in well preserved samples of molasses silage as shown in Tables III and V. Again in spite of the high digestibility of the protein of the immature grass that of the silage produced from it was very low.

The very pronounced increase in the percentage of ether extract and crude fibre also showed in a striking manner that the ensilage of rain-soaked immature grasses was accompanied by extensive chemical changes. There are always in silage acids and bases of a volatile nature formed as a result of the breaking down of carbohydrates and proteins. In this sample, however, these are present in excessive amounts as evidenced by its objectionable odour and the abnormally high values found for these constituents in comparison with those in the silage made from the more mature fodder. Table VI illustrates these

differences, and Sample I may be taken as characteristic of sour, partially spoilt silage.

TABLE VI.

The average percentage of volatile bases (expressed as crude protein) and volatile acids (expressed as acetic acid) in the three samples of silage made in 1934.

Sample.	*1*	*2*	*3*
Volatile bases	1.21	0.43	0.31
Volatile acids	1.16	0.68	0.63

The high protein content, immaturity and rain-soaked condition of the grass doubtless accounted for the sour silage produced. With all its drawbacks, however, it was surprising to find that the stock consumed a considerable amount of the material.

One important conclusion may be drawn from this particular type of silage, namely that young grass in a rain-soaked condition is quite unsuitable for making silage, and that contrary to what is frequently stated, ensilage does not appear to be wholly independent of weather conditions.

The two samples of silage numbered two and three made by the same process from more mature grass, show changes of a similar nature to those discussed above, though they have not proceeded as far in these samples.

TABLE VII.

Whey Silage, 1934.

	Grass.	*Silage Edge.*	*Silage Central.*
Water	82.4	84.2	83.6
Dry matter	17.6	15.8	16.4
	Based on	dry matter.	
Ether extract	3.66	3.71	5.81
Crude protein	13.64	13.98	10.59
True protein	8.95	11.85	9.03
Digestible protein	11.00	4.89	5.64
Fibre	30.80	31.66	32.30
Ash	8.58	9.47	9.77
Soluble Carbohydrates	43.82	41.18	41.53
Phosphoric Acid (P_2O_5)	0.74	0.61	0.61
Lime (CaO)	0.68	0.67	1.14

In 1934, another type of silage was made which is described as whey silage, for in its preparation whey was sprinkled on the grass in the process of filling the silo at the rate of one gallon

per cwt. of grass. The same principle is involved in the addition of whey as in the case of molasses, both supplying a fermentable sugar—in whey lactose or milk sugar—which rapidly produces lactic acid. Table VII, on p. 139, gives the chemical composition of the grass together with the average composition of the silage samples taken from the edge and from the centre of the silo.

The grass was cut and ensiled on the 7th of June, 1934, and was slightly more mature than the three grasses made into molasses silage. (See Table V). The product, judged by its chemical composition, compared favourably with the better type of molasses silage and was readily consumed by the cattle to which it was fed, though not eaten with quite the same relish as the molasses silage.

The effect of ensiling on the mineral content of the original fodder is of interest, and in Table VIII the percentage of lime, phosphoric acid, potash and chlorine in the dry matter of the grass and silage is given.

TABLE VIII.

Material.	*Lime* CaO	*Phosphoric Acid* P_2O_5	*Potash* K_2O	*Chlorine* $Cl.$
Clover rye grass	2.44	0.68	1.60	0.90
Ordinary silage	2.75	0.63	1.83	0.85
Grass ..	0.71	0.52	3.58	1.38
Molasses silage	1.07	0.50	3.31	1.39
Very immature grass	0.69	0.90	4.20	1.26
Molasses silage (sour)	0.80	0.46	3.46	1.07
Grass . .	0.68	0.74	3.71	1.33
Whey silage	—	0.61	3.55	1.34
Grass ..	0.71	0.52	2.20	0.92
A.I.V. silage	0.91	0.50	2.44	1.38
Grass	0.71	0.52	2.36	1.07
Defu silage ...	0.80	0.57	2.76	1.72

From the results given in the table it is evident that the dry matter of the silage is, generally speaking, richer in lime and poorer in phosphoric acid than the grass ensiled, while the potash and chlorine content shows no regular variation. Here again the results for the immature, rain-soaked grass and the resulting silage are very significant, for with the exception of the lime there has been a decrease in the amount of each constituent as a result of ensilage. This, taken in conjunction with what has already

been said with regard to the effect on the other constituents of immature rain-soaked grass, leaves little doubt as to the unsuitability of such material for ensiling.

One of the chief objects in making silage is to reduce the loss of nutrients which occurs in preserving fodder in unfavourable weather by the old established method of hay making. Of the acreage of grass reserved for the making of silage and hay in 1933, four-fifths were made into four different types of silage and one-fifth into hay. The chemical composition of the grass cut for hay on the 1st of July, 1933, as harvested on the 4th of the same month and at the time when the stack was opened on the 11th of November of that year is given in Table IX.

TABLE IX (1933).

Material. *Date of sampling.*	*Grass.* *1/7/33.*	*Hay.* *4/7/33.*	*Hay.* *14/11/33.*
Moisture	64.2	14.3	11.6
Dry matter	35.8	85.7	88.4
	Based on	dry matter.	
Ether extract	3.05	2.30	2.95
Crude protein	9 53	9.53	10.19
True protein	8.00	7.87	8.83
Digestible protein	6.82	6 88	7.03
Fibre	28.70	28.20	28.60
Ash	4.50	5.62	5.97
Soluble Carbohydrates	54.22	54.35	52.29
Phosphoric Acid (P_2O_5)	0.38	0.37	0.40
Lime (CaO)	0.70	0.77	0.84

The conditions of harvesting in 1933 were exceptional, for from the date of cutting until carting to the stack no rain fell. The grass made into hay in comparison with that made into silage was more mature, being cut some fourteen days later and, in consequence, was richer in dry matter. In the making of the hay most of the moisture was lost giving a product containing 85 to 88 per cent. of dry matter, while in comparison the percentage of dry matter in the silage differs only slightly from that of the original fresh fodder.

The results given in Table IX show that there has been but little change in the percentages of the constituents determined in the dry matter as a result of hay making, and that the digestibility of the crude protein of the hay compares favourably with that of grass and good silage. There appears to have been no appreciable breakdown of protein during the process of hay making which in this respect differs very materially from the making of silage. The making of hay has been accompanied by

small increases in the percentages of ash and lime, which are probably due to the losses in organic matter owing to fermentation.

In 1933 a comparison of the loss of dry matter in the making of silage and hay was attempted. In order to assess the loss in hay making ten swathes of the grass were weighed immediately after cutting and again before carting, and from each of these representative samples were taken in which the dry matter was determined. With this data the loss of dry matter undergone by the hay in its making in the field was calculated. When the hay was carted to the stack, known weights were placed in ten marked jute bags and these placed in the stack where they remained until the hay was required, when the contents of the bags were again weighed. Representative samples of the hay in each bag were taken for dry matter determinations both when placed in the stack and when taken out, and from this data the loss of dry matter in the stack was calculated.

The average result of the ten determinations made at each stage in the making of the hay showed that 10 per cent. of the dry matter was lost in the field and 16 per cent. in the stack during storage, making a total of 26 per cent. From this it is seen that although the season was exceptionally well suited for hay making, the loss of dry matter was much in excess of that which took place when similar material was made into molasses, Defu and A.I.V. silage. (See Table IV). The above may be taken as the minimum loss in the making of hay, for the grass was cut early and no seed was lost, it was dealt with in ideal weather under experimental conditions, when all necessary care was taken. Under average conditions of cutting, weather and general management the losses would undoubtedly have been greater.

Summary and Conclusions.

The five methods employed in the making of silage produced fodder which compared favourably in chemical composition with the green crop ensiled, and in reaching any conclusion as to the relative merits of these methods the losses of dry matter become of prime importance. From this point of view, the results obtained in this investigation indicate that the molasses and Defu methods are well suited for preserving grass. The A.I.V. method is less efficient, while the ordinary method is unsuitable.

The state of maturity of the crop ensiled is of the highest importance, for this investigation has shown that some of the

changes which lead to losses in nutritive value and palatability were more pronounced when relatively immature crops were ensiled, such changes being especially marked in the wet immature grass employed.

The molasses silage when fed to the stock was eagerly consumed, and no difficulty was experienced in getting them to eat the ordinary and whey silage. On the other hand, the A.I.V. and Defu silage was but reluctantly eaten, and some time was taken before they became accustomed to it.

All the animals fed with silage did well and suffered no ill effects from the consumption of the silage in the preservation of which mineral acid had been used. It should be mentioned that as a precautionary measure a little carbonate of lime was incorporated in their ration.

When the chemical composition, loss of dry matter and palatability of the silage prepared are taken into consideration the molasses method appears to be the one best suited for preserving grass.

In comparison with hay making ensilage by the molasses, Defu and A.I.V. methods involved much smaller losses of dry matter.

In addition to the above advantages the making of silage is a convenient and useful means of dealing with a luxuriant aftermath which often cannot be harvested or closely grazed, and with surplus grass which is frequently available in late spring and early summer.

Finally, silage can be successfully made at almost any time, from a variety of crops, while for successful hay making ideal weather conditions are essential. The highly nutritious nature of silage made from young grass, together with the fact that it provides a succulent fodder at almost any period of the year, should render it increasingly popular in a country such as Wales, where grassland farming, stock raising and milk production are so extensively practised.

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THE CHEMICAL COMPOSITION OF THE STRAW OF STRONG AND WEAK-STRAWED VARIETIES OF OATS.

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The problem of producing oat varieties resistant to lodging is one with which the plant breeder is constantly concerned. This is particularly the case in such countries as Wales and Scotland where the crop is frequently lodged, making it extremely difficult and costly to harvest and on occasions rendering it more or less valueless. Crops damaged in this way were a familiar sight in Wales during the wet season of 1936, and are of common occurrence in the more hilly regions where inclement weather conditions prevail. It is therefore not surprising that in some parts of Wales strength of straw and crop yield are regarded as being of equal importance(1).

The disadvantages of a lodged crop are many, the most important probably being the difficulty experienced in harvesting operations, the production of badly filled grain in consequence of the incomplete transference of nutrients from the straw, and the damage done to young seeds where oats is the nurse crop.

Investigations have shown that lodging is most liable to occur on heavily manured soils, when an oat crop follows a ley containing large amounts of clover, when heavy rain follows a period of very active growth, and where the sowing has been late or very heavy (2) (3). Although some varieties have greater power to resist lodging than others, the reason for this is obscure. The tendency to lodge has been attributed to a variety of causes such as the deficiency of a particular constituent, for example "fibre," silica, minerals or lignin, and to such factors as the length of the straw and weakness of the root system (4) (5).

The production of oat varieties resistant to lodging is a problem to which the staff of the Welsh Plant Breeding Station

has naturally devoted considerable attention. In 1933, an investigation was conducted with the object of studying the chemical composition of the straw of different varieties possessing varying powers of resistance to lodging. Since it is a well known fact that the tendency of a crop to lodge is greater when the rate of seeding is heavy, it was considered that an attempt should also be made to determine whether the chemical composition of oat straw is affected by the rate of seeding employed. With these objects in view the chemical composition of the straw of strong and weak-strawed varieties was examined.

The varieties grown together with the rate of seeding are given in Table I. The amount sown corresponds with that normally used in the locality (for example, Record Oats sown at the rate of 200 lb. per acre) and takes into account the greater tillering capacity of such varieties as Radnorshire Sprig, Ceirch-du-bach and Ceirch Llwyd (Avena strigosa).

TABLE I.

Variety.	*Rate of seeding in grams per furrow.*
(Grey Winter × Kyko) × (Grey Winter × Bountiful)	15.0
Victory × Red Algerian	15.6
Record	15.6
Marvellous	15 6
Abundance	15.6
Radnorshire Sprig	14.0
Grey Winter	15.0
Ceirch-du-bach ...	12.6
Ceirch Llwyd	12.6

Each variety was sown in a plot consisting of eight furrows twelve feet long, the plots being separated by two blank furrows. When they had reached the same degree of maturity samples were taken from the outer and central furrows of each plot. These were kept apart and analysed separately and the central samples taken to represent growth under field conditions, whilst the outer samples, as is the case with all experimental plots, were subject to different conditions of growth generally referred to as " border effect." After harvesting and threshing, the leafy material present was removed and the straw alone ground to the same degree of fineness for analysis (passing a 1/64th inch sieve of a Christy and Norris Mill). The removal of the leaves made possible a more accurate comparison of the percentages of fibre and

mineral constituents present in the various straws. The percentages of the mineral constituents given in this paper are expressed on the dry matter.

Table II gives the percentage of crude fibre and silica present, while the information given under the heading "Strength of Straw" is the result of the experience of farmers and plant breeders.

TABLE II.

Variety.	*Strength of Straw*	*Crude Fibre.*		*Silica.*	
		Straw from the centre of the plot	*Straw from the border of the plot*	*Straw from the centre of the plot*	*Straw from the border of the plot*
(Grey Winter × Kyko) × (Grey Winter × Bountiful)	Very strong	44.6	43.3	1.91	2.03
Victory × Red Algerian	Strong	46.5	45.7	1.45	1.28
Record	Strong	45.7	45.7	1.32	1.35
Marvellous	Strong	45.3	45.1	1.43	1.17
Abundance	Fairly weak	46.1	46.0	1.24	0.98
Grey Winter	Weak	45.5	44.0	1.30	1.50
Radnorshire Sprig	Weak	46.0	45.8	1.09	1.27
Ceirch-du-bach	Weak	48.3	47.7	1.21	1.11
Ceirch Llwyd	Weak	49.8	49.2	0.94	0.90

It will be seen from these results that the percentage of crude fibre in the straw from the centre and border of the plots is in the majority of cases very similar. The strong straws, however, contain a lower percentage of fibre than the weak straws, the average percentages present being 45.2 and 47.0 respectively. It seems probable therefore that resistance to lodging is not determined merely by the quantity of crude fibre present. On the other hand, the strong straws contain a higher percentage of silica than the weak straws, a fact which supports the theory that resistance to lodging is due to the silica content. The percentage present in the new variety (Grey Winter × Kyko) × (Grey Winter × Bountiful) is interesting in this respect for in its selection strength of straw was the main object in view. This variety has a short stout straw which has shown remarkable resistance to lodging in comparison with other varieties and, as shown in Table II, it has a much higher percentage of silica than any of the others studied. Evidence in support of the above theory has been advanced by Phillips, Davidson and Weihe, who showed that manuring with sodium nitrate which frequently causes lodging also resulted in a distinct decrease in the silica content of the straw(6).

Although the figures presented in Table II indicate that strength of straw is associated with a relatively high silica content and a relatively low content of fibre, the variety Grey Winter is

TABLE III.

Variety	*Strength of Straw.*	*Ash*		*Silica Free Ash*		*Phosphoric Acid (P_2O_5.)*		*Lime (CaO.)*		*Potash (K_2O.)*		*Chlorine (Cl.)*		*Crude Protein.*	
		Centre	*Edge.*	*Centre*	*Edge*	*Centre*	*Edge.*	*Centre.*	*Edge.*	*Centre.*	*Edge*	*Centre.*	*Edge.*	*Centre.*	*Edge.*
(Grey Winter × Kyko) × (Grey Winter × Bountiful	Very Strong	5.29	6.05	3.35	4.02	0.31	0.35	0.42	0.42	1.54	1.79	0.78	1.02	2.55	2.96
Victory × Red Algerian	Strong	4.75	5.59	3.30	4.31	0.21	0.16	0.38	0.35	1.16	1.24	0.70	1.07	2.08	2.15
Record	Strong	4.66	5.22	3.34	3.87	0.18	0.16	0.31	0.36	1.19	1.28	0.74	0.92	1.88	2.48
Marvellous	Strong	4.89	5.46	3.46	4.29	0.25	0.20	0.37	0.33	1.27	1.31	0.84	0.99	1.53	2.02
Abundance	Fairly Weak	5.38	5.59	4.14	4.61	0.23	0.15	0.39	0.32	1.46	1.25	1.01	1.09	1.70	1.78
Grey Winter	Weak	4.68	4.85	3.38	3.35	0.24	0.21	0.37	0.34	1.43	1.33	0.87	0.92	2.52	2.63
Radnorshire Sprig	Weak	4.01	4.71	2.92	3.47	0.18	0.18	0.32	0.34	1.21	1.54	0.59	0.76	1.97	1.83
Ceirch-du-bach	Weak	3.98	4.30	2.77	3.20	0.10	0.21	0.29	0.30	1.12	1.06	0.57	0.66	1.57	2.01
Ceirch Llwyd	Weak	3.17	4.11	2.22	3.21	0.09	0.12	0.32	0.35	1.04	1.22	0.44	0.71	1.69	1.98

exceptional in both respects. Omitting this variety, the average percentage of silica in the strong and weak straws is 1.5 and 1.1 respectively. However, as previously noted in the case of the fibre content, there appears to be no general well marked differences in the silica content of the straw from the centre and border of each plot.

The differences in silica content suggest that there might be differences in the percentages of other ash constituents and these together with the percentage of crude protein in both the strong and weak straws are presented in Table III.

These results show that on the average the strong straws are richer in ash, silica free ash and chlorine than the weaker straws, while as pointed out previously in the case of the fibre and silica content, the variety Grey Winter is rather exceptional in this respect. The difference in mineral content is shown most clearly when the more extreme varieties are compared, the very strong straw of the new variety, for example, being much richer in all the ash constituents determined than the weak straw of Ceirch-du-bach and Ceirch Llwyd. These differences are shown by both the samples taken from the centre and from the edge of the plots.

Moreover, the samples grown at the centre of the plot are poorer in ash, silica free ash and chlorine than those from the edge, where the growth was less restricted and the individual plants very strong.

It therefore appears that under ordinary field conditions plants absorb much smaller quantities of soil nutrients than where growth is less restricted. This contention is supported by the fact that the percentage of crude protein is, with one exception, higher in the samples taken from the edge of the plots, whereas the ether extract, crude fibre and soluble carbohydrates show no such variation; of these the protein alone depends directly upon soil nutrients for its formation.

The data already presented show that the chemical composition of oat straw depends to some extent upon the conditions of growth, and further evidence in support of this was obtained from a study of the straw from plots sown at the normal rate and double the normal rate, respectively.

Table IV gives the varieties sown, together with the rate of seeding which, as in the previous investigation, takes into account the tillering capacity of each variety.

TABLE IV.

Variety.	*Rate of seeding in grams per drill.*	
	A. Series.	*B. Series.*
(Grey Winter × Kyko) × (Grey Winter × Bountiful)	5	10
Victory × Red Algerian .	6	12
Elder	6	12
Record	6	12
Marvellous	6	12
Yielder × Golden Rain	6	12
Victory ..	6	12
Abundance	6	12
Grey Winter . ..	5	10
Radnorshire Sprig	5	10
Ceirch-du-bach	4.5	9
Ceirch Llwyd . ..	4	8
Ceirch Llwyd Cwta .	4	8

The varieties were sown in two plots, the rate of seeding being normal in the A and double that amount in the B plots. Each plot was made up of three furrows four feet six inches long. The varieties were harvested at the same stage of maturity, threshed and ground as previously described, the samples being taken from the centre of each plot.

TABLE V.

Gives the percentage of crude protein, ether extract, crude fibre and soluble carbohydrates in the straw from the A and B series of plots.

Variety	*Crude Protein.*		*Ether Extract.*		*Crude Fibre*		*Soluble Carbohydrates*	
	A	B	A.	B	A	B.	A	B
(Grey Winter × Kyko) (Grey Winter × Bountiful)	8.01	4 88	2 36	2 20	40.6	44 0	42.4	44 2
Victory × Red Algerian	4 20	2 90	1 42	2 45	43 3	45 5	44 0	43.6
Elder.	3 46	2 92	2 01	2.55	47.5	47.1	41 3	42 7
Record	2 55	2.38	1.06	2 01	45 3	46.0	44 0	44 2
Marvellous	3 54	2.02	1 60	1 63	44.7	46 6	44.5	44.8
Yielder × Golden Rain	4.64	2 45	1.53	2.50	41.9	46 8	45.5	43.2
Victory	4.88	3.19	1.63	1.79	44 8	44.9	43 1	44 4
Abundance	3.82	3.64	1 57	1.68	46.3	45 1	42.5	44.2
Grey Winter	5.91	2 83	1.55	2 04	41.8	48 2	44.7	42.6
Radnorshire Sprig	3.84	3.03	1.47	2 34	47.2	49.1	43 0	42.6
Ceirch-du-bach	4.70	3.04	1.56	2.12	44 1	48 9	44.6	41.5
Ceirch Llwyd Cwta	3 95	2.85	1 56	1.60	46 5	47.5	42.8	44 2
Ceirch Llwyd	5.89	4.04	1 63	2 05	43.4	45 1	43.3	44.7

From the figures in Table V it is evident that compared with the normal rate, heavy seeding has produced straw with a much lower percentage of protein and in most cases a higher percentage of ether extract and crude fibre, the soluble carbohydrates showing no regular variation. This result is of interest seeing that it was previously shown in Table III that the straw grown under field conditions contained a lower percentage of crude protein

than that from the edge of the plots. The percentages of ash, silica and silica free ash in the straw from the A and B series of plots are given in Table VI.

TABLE VI.

Variety.	*Ash.* *A.*	*Ash.* *B.*	*Silica.* *A.*	*Silica.* *B.*	*Silica Free Ash.* *A.*	*Silica Free Ash.* *B.*
(Grey Winter x Kyko) x (Grey Winter x Bountiful)	6.51	5.72	1.78	1.91	4.73	3.81
Victory x Red Algerian	6.95	5.51	1.06	1.62	5.89	3.87
Elder	5.66	4.82	1.27	1.32	4.38	3.50
Record	6.03	5.48	1.18	1.58	4.86	3.90
Marvellous	5.68	4.97	1.09	1.27	4.59	3.70
Yielder x Golden Rain	6.34	5.00	1.25	1.35	5.09	3.65
Victory	5.72	5.66	1.18	1.38	4.54	4.28
Abundance	5.72	5.27	1.05	1.49	4.67	3.78
Grey Winter	5.89	4.37	1.08	1.24	4.81	3.14
Radnorshire Sprig	4.49	3.27	1.15	1.42	3.34	1.85
Ceirch-du-bach	4.95	4.48	1.08	1.16	3.87	3.32
Ceirch Llwyd Cwta	5.20	3.61	0.87	1.01	4.33	2.60
Ceirch Llwyd	5.67	4.04	0.90	1.14	4.77	2.90

From Table VI it is seen that heavy seeding has resulted in a lower percentage of ash and silica free ash, but in a higher percentage of silica. As in the previous Table the varieties were arranged in the order of their ability to resist lodging and the figures provide further information indicating that the stronger straws have the higher content of ash constituents. The difference in the amount of silica free ash in the straws from the A and B plots is reflected in the amount of certain mineral constituents given in Table VII.

TABLE VII.

Variety.	*Phosphoric Acid.* (P_2O_5) *A.*	*Phosphoric Acid.* (P_2O_5) *B.*	*Lime.* (CaO) *A.*	*Lime.* (CaO) *B.*	*Potash.* (K_2O) *A.*	*Potash.* (K_2O) *B.*	*Chlorine.* (Cl) *A.*	*Chlorine.* (Cl) *B.*
(Grey Winter x Kyko) x (Grey Winter x Bountiful)	0.21	0.20	0.38	0.41	2.31	1.52	1.44	0.95
Victory x Red Algerian	0.09	0.07	0.37	0.35	2.07	1.74	1.38	0.81
Elder	0.08	0.06	0.31	0.33	1.34	1.66	1.05	0.62
Record	0.07	0.06	0.36	0.29	0.96	1.87	0.91	0.77
Marvellous	0.08	0.07	0.33	0.32	1.85	1.20	1.09	0.65
Yielder x Golden Rain	0.10	0.07	0.31	0.38	1.93	0.99	1.40	0.67
Victory	0.10	0.08	0.30	0.35	1.91	1.14	1.25	0.82
Abundance	0.08	0.07	0.41	0.36	1.60	2.05	1.06	0.82
Grey winter	0.13	0.07	0.33	0.32	2.37	1.60	1.36	0.74
Radnorshire Sprig	0.07	0.05	0.32	0.37	1.24	1.21	0.58	0.18
Ceirch-du-bach	0.10	0.07	0.33	0.33	1.22	1.10	1.05	0.55
Ceirch Llwyd Cwta	0.08	0.07	0.40	0.37	1.44	0.76	1.30	0.50
Ceirch Llwyd	0.15	0.10	0.46	0.49	2.17	0.80	1.47	0.60

Without exception, the percentage of chlorine is higher in the straw from the A plots than in that from the B plots and, with a few exceptions, the same is true of the percentage potash. The phosphate content of the straw is low, but the differences, though small, follow the same trend as the differences in potash and chlorine content. The percentage of lime, however, shows no regular variation.

Summary.

This paper describes an investigation into the chemical composition of the straw of oat varieties possessing varying powers of resistance to lodging and also the effect of rate of seeding on the composition of such straw. For this purpose old and new varieties were grown to the same stage of maturity, the straw being stripped of leaves and analysed after grinding to the same degree of fineness.

The results obtained indicate that in most cases strength of straw was associated with a relatively high content of certain ash constituents, particularly silica, and a low fibre content; further, that the straw from the border of the plots was richer in the constituents obtained from the soil than that from the centre where growth was more restricted. A somewhat similar result was obtained when the effect of rate of seeding was investigated, for heavy seeding resulted in lower percentages of protein and certain ash constituents but in higher percentages of fibre and silica.

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THE DEVELOPMENT OF CERTAIN GRASSES AND CLOVERS DURING THE SEEDING YEAR.

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Problems associated with growth and establishment of various pasture plants during their first year have been studied critically at the Welsh Plant Breeding Station, and a number of separate reports connected therewith have already been made. The present paper deals with certain aspects of the same problem, and in particular with percentage establishment and growth during the first few weeks after sowing. Data are reviewed relative to perennial rye-grass, cocksfoot, timothy, red clover and white clover. In the case of the grasses two contrasting strains (pedigree and commercial) of each have been under test—the pedigree strain bred at the Station and specifically developed because of its desirable attributes as a pasture plant.

The trial under review was laid out on a field (adjoining the Station farm) which had been leased by the Station for experimental purposes. The field has a general south-westerly slope, is nowhere steep, and lies at an elevation of between 300—400 ft. The soil is a light stony loam typical of the sedentary soils derived from Ordovician rocks in Central and South Wales. Prior to 1931, when the field was ploughed, it had been down to grass for a number of years. An oat crop was taken in 1931, no manures having been applied. In November, 1931, the field was top dressed uniformly with half-a-ton per acre of shoddy; this was ploughed in immediately. The seeds mixture trial with which we are now concerned was sown on prepared land on June 2nd, 1932. Altogether forty-four different seeds mixtures were used; these were replicated eight times and this involved a total of 352 plots, each 1/200th acre in size. The plots were so arranged that alternate rows could be dressed with basic slag without undue interference with the general design of the experiment. The slag ($15\frac{3}{4}$ per cent. P_2O_5) was applied approximately one month after sowing the seeds, and at the rate of 6 cwt. per acre. The present article deals with data from only forty (out of a total of forty-four) different seeds mixtures.

A more detailed account of the seeds mixtures used and the general lay-out of the trial is given elsewhere (1). It is sufficient to note here that the seeding year data may be conveniently grouped to show :—

(1) Average percentage establishment in the sown species.
(2) Establishment of pedigree and commercial strains.
(3) Influence of grass competition upon the clovers.
(4) Influence of red clover upon the grasses.
(5) Influence upon growth when basic slag is applied one month after seeding.

TABLE I.

To show (a) number of rainy days; (b) inches of rain; and (c) mean temperature; for ten and thirty day periods following sowing; 1932 compared with eight years average.

	Period of ten days thereafter			*Period of thirty days thereafter.*		
	No. of rainy days.	*Inches of rain.*	*Mean temperature*	*No. of rainy days.*	*Inches of rain.*	*Mean temperature*
1932	2	0.66	52.3	7	1.21	56.9
Previous 8 years average	4.5	1.3	54.7	12.5	3.5	54.6

Weather conditions after sowing.

It will be seen from Table I that the weather during the thirty-day period following date of seeding was markedly dry, with temperatures above the average. No rain fell until the tenth day after sowing, when there was an aggregate fall of nearly two-thirds of an inch; this was followed by a dry spell when no rain was recorded for thirteen days and when fairly high mean temperatures ranging between 53° F. and 65° F. were recorded. The weather conditions during this first thirty-day period were therefore not such as to be conducive to either rapid growth or to a high rate of establishment. The heavy rain on the tenth day would hasten germination, only for many of the seedlings to be killed off in the course of the subsequent dry spell. Weather conditions such as these, however, are not wholly abnormal at Aberystwyth, and can be expected to recur at not infrequent intervals.

Average percentage establishment of sown species.

The data brought forward in Table II are in general conformity with a large body of parallel results collected over a

period of years at Aberystwyth. There is, for example, a general relationship between the size of " seed," as measured by the weight per 1,000 " seed," and the figure for percentage establishment. This feature, for example, is shown in extreme when commercial perennial rye-grass (weight per 1,000 seed = 1.980 gm.) is compared with pedigree timothy (weight per 1,000 seed = 0.255 gm.). When pedigree and commercial perennial rye-grass are compared the same trend is evident though the difference is of course more narrow.

TABLE II.

Percentage establishment* of the sown species at five (July) and ten (August) weeks after sowing, 1932.

Species.	*First count (July).*	*Second count (Aug.).*	*Second count as percentage of first count*	*Grain weight (= wt. per 1,000 seeds).*
Perennial rye-grass (pedigree—S.23)	23.8	13.8	58	1.215
Perennial rye-grass (commercial)	41.0	25.5	62	1.980
Cocksfoot (pedigree—S.26)	16.9	17.6	104	0.849
Cocksfoot (commercial)	24.0	18.1	75	0.880
Timothy (pedigree—S.48) .	17.0	9.0	53	0.255
Timothy (commercial) .	26.9	15.0	56	0.322
Montgomery red clover	43.7	31.4	72	1.870
Wild white clover .	31.9	23.3	73	0.530
Average (8 lots)	28.0	19.2	69	

* Percentage establishment = $\left\{\frac{\text{No. plants per square foot}}{\text{No. viable seed per sq. foot}}\right\} \times 100$

The data in respect of the clovers do not appear to fit so well, and this again is in general agreement with earlier results. Establishment calculations in the clovers, however, may be influenced appreciably by the proportion of hard seeds contained in the samples. This is often true of samples showing low laboratory germination and in which the proportion of hard seeds may be very high. In the present trial, for instance, the sample of white clover used had a real value[1] of only 62 per cent. and no account was taken of its content of hard seeds. There is some ground for supposing, however, that many (if not the majority) of the hard seeds in clover samples do in fact germinate in the field.

[1] Real value = $\frac{\text{purity} \times \text{germination}}{100}$

A point of some interest emerging from Table II is the very appreciable fall in percentage establishment during the few weeks immediately following the first big flush of germination in the field. This fall is not limited to any particular species, but appears to be general, although in the present trial pedigree cocksfoot has been an exception, its numbers having increased slightly from the first to the second count. In this instance (pedigree cocksfoot), however, the figure for the first count is exceptionally low, and it is evident that the readings were taken before the initial flush of germination had been completed. Taking the average of all species and strains under test, the numbers on the second count were only 69 per cent. of those occurring at the first count.

It seems, therefore, that quite soon after the first phase of active germination in the soil the seedling population is at its greatest density, and there follows a rapid diminution in numbers, this process probably going on throughout the first summer. This is carried still further during the course of the following winter and spring. There is evidence, however, which suggests that a certain amount of delayed germination also takes place and that this may occur in certain species as late as the second harvest year. In most instances, however, it is likely that the gain in numbers consequent upon delayed germination is more than offset by the casualties. That this is true during the seeding year in particular is strongly indicated by the present data.

TABLE III.

Percentage establishment and real value in the pedigree and commercial strains of grasses (average of two counts for establishment). Seeding year 1932.

Species.	*Pedigree.*		*Commercial.*	
	Percentage establishment.	*Real value per cent.*	*Percentage establishment.*	*Real value per cent.*
Perennial rye-grass	17.8	72	32.0	89
Cocksfoot	17.5	87	20.9	86
Timothy	13.7	89	18.0	97
Average establishment	16.3	—	23.6	—
Relative average with commercial = 100 ..	69	—	100	—

Percentage establishment in pedigree and commercial strains.

Table III shows that the pedigree (pasture) strains of perennial rye-grass, cocksfoot and timothy under test have on

the average established themselves only about two-thirds (69 per cent.) as well as their commercial counterparts. The relatively poor capacity for establishment in the field displayed by many of the pasture strains has been a feature of most of the Aberystwyth trials. The use of seed harvested locally (under adverse weather conditions) has no doubt partially accounted for this lower standard of soil germination. There is, however, a good deal of accumulated evidence which goes to show that the pasture strains do not have the same inherent ability for rapid growth as have commercial strains. Pasture strains also have usually smaller seeds than the commercial, and that in itself would tend to promote a lowering of establishment under field conditions.

While this knowledge has direct practical implication yet the lower rates of establishment do not greatly (if at all) detract from the agricultural value of these pedigree pasture strains. The normal rates of seeding used in current seeds mixtures are in fact sufficiently liberal to offset completely the adverse effect of these lower potential rates of establishment. Thus, having regard to both size of seed and percentage establishment, a moderate sowing of 14 lb. per acre of perennial rye-grass (S.23) might be expected to provide about 16 mature plants per square foot, whereas the comparable figure, if commercial seeds were used, would be approximately 19 plants.[2] Having regard to the greater tillering capacity of the pedigree strain and the lack of persistence normally associated with commercial strains of rye-grass, it is obvious that this small handicap in the number of plants initially established would be rapidly overcome.

TABLE IV.

Percentage establishment of Montgomery red and wild white clovers when sown in competition with the various grasses (average results for two counts); seeding year 1932.

Associated grass(es) in mixture.	*Percentage establishment.*	
	Montgomery red clover.	*Wild white clover.*
Perennial rye-grass ..	26.4	18.1
Cocksfoot ..	33.1	23.4
Timothy	31.6	25.0
All three grasses in combination ..	—	14.2
One grass alone ..	—	22.2
One grass + red clover .	—	22 1

[2] These calculations are based upon data from the experiment under review. The proportions would probably hold good generally, although the actual numbers would vary on different grades of soil.

Influence of the grasses upon the establishment of the clovers.

The results shown in Table IV indicate very definitely that competition between species in the sward reacts upon establishment almost from the commencement. . The data are based upon the average of two independent sets of readings taken approximately five and ten weeks after sowing. Even at this early stage perennial rye-grass is shown to be definitely more aggressive towards the clovers than is either cocksfoot or timothy. Rye-grass has caused an appreciable lowering of percentage establishment in both red and white clovers. Cocksfoot over the same period has proved more aggressive than timothy, findings which are altogether in keeping with previous evidence.

On the average the combination of any two of these grasses has had a more adverse influence upon white clover than when each is used singly. Montgomery red clover appears to have had no influence upon this initial establishment of white clover, whereas there are indications that the red clover promoted better establishment in the three grasses grown with it. This point is referred to in greater detail below.

TABLE V.

The influence of red clover on the establishment of the grasses; seeding year 1932.

Species.	*Percentage establishment of the grasses when*	
	Sown without red clover.	*Sown with red clover.*
Perennial rye-grass (pedigree S.23)	13.2	13.9
Perennial rye-grass (commercial)	21.6	25.8
Cocksfoot (pedigree—S.26)	17.1	17.7
Cocksfoot (commercial)	16.7	18.6
Timothy (pedigree—S.48)	10.4	8.6
Timothy (commercial)	13.7	15.4
Average (6 strains)	15.9	16.7
Relative average	(100)	(105)

Influence of red clover upon establishment of the grasses.

Table V shows the percentage establishment in the grasses under test when these were sown in mixtures without red clover and in mixtures containing red clover. There appears to be a perceptible improvement in the establishment of the grasses when sown with red clover. It will be noted that this is borne out by each of the grass strains with the one exception of pedigree timothy. No attempt can here be made to assess the full

significance of the value of clover and its influence upon grasses. It is, however, important to note that the data shown in Table V are based on readings all of which were made within ten weeks of the day of sowing. The rapidity with which the clover has affected the grasses, therefore, is of considerable importance. The results obtained here under field conditions are of special interest in view of findings recently reported by Virtanen (2). These indicate that nitrogenous residues are excreted from the root nodules of legumes at quite an early stage of growth of the host plant. These findings may explain the rapidity with which the grasses improve in colour and then in vigour after clover has gained entry into pastures previously devoid of legumes.

TABLE VI.

To show effect of basic slag on tillering in the grasses, and upon number of plants in the clovers (ten-eleven weeks after sowing). Seeding year 1932.

Species.	*With slag.*	*No slag.*	
* Perennial rye-grass .	100	86	85
* Cocksfoot	100	89	
* Timothy .	100	80	
† Montgomery red clover .	100	103	104
† Wild white clover ..	100	105	
* *Agrostis* (unsown) ...	100	125	

* Grasses – tillers per unit area.
† Clovers = plants per unit area.

Influence of basic slag.

The seeds were sown on June 2nd, 1932, and the slag was applied to one half of the plots one month later (four replications each of " slag " and " no slag.") The botanical analysis was carried out during the latter part of August, 1932, ten or eleven weeks after seeding and some seven weeks after the application of basic slag. Table VI summarizes the evidence accumulated. The data for the grasses are based upon the *number of tillers* per unit of area, while those for the clovers are based on *number of plants.* To bring the whole to a common basis, the figures for " with slag " are placed at 100 for each species, and the comparative figures for " no slag " are expressed as a percentage of these.

The data are noteworthy to the degree in which they show that within a very short period after its application basic slag has promoted quite sharp responses. This result has been commonly observed in our trials and is now to be regarded as a

quite definite reaction under Welsh conditions. In the present trial slag has increased tiller production in rye-grass, cocksfoot and timothy, while it has caused a marked inhibition of tillering in (unsown) *Agrostis*. This is obviously a direct reflex of increased vigour in the sown grasses which in itself would help to retard the spread of unsown species.

It is less easy to explain the slight decrease in the number of clover plants found on the slag plots. There is on the one hand no doubt that slag promotes the growth of clover, particularly on phosphate-deficient soils such as that with which we are now dealing. On the other hand, it has been shown above that the clovers, during their initial stages of establishment, are extremely susceptible to small changes in sward competition. Thus it is suggested that while slag has tended to favour development in the clovers the increased vigour which the manure has promoted in the grasses has more than offset the stimulating influence of slag, and the sum effect has been a slight decrease in the clover content. A somewhat analagous result was reported by one of us in 1927 (3).

Summary.

(1). The paper deals with experimental data collected upon plots in the seeding year (1932).

(2). Subsequent to the peak of soil germination there is a marked diminution in numbers of survivor seedlings. The establishment is shown to have fallen by 31 per cent. between July and August (seeding year).

(3). Pedigree (pasture) strains have established only about two-thirds as well as the commercial lots.

(4). Interspecific competition has a reaction upon the constitution of the sward even as early as five weeks after sowing. Perennial rye-grass is particularly aggressive during this early period.

(5). Red clover has improved the percentage establishment of the grasses sown with it.

(6). Basic slag has encouraged the sown grasses, but has depressed red and also white clover when these species are sown with grasses. *Agrostis* (unsown) is also depressed.

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FIELD TRIALS WITH PEDIGREE AND INDIGENOUS STRAINS OF GRASSES.

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A number of experiments which have been conducted at the Welsh Plant Breeding Station farm have shown that pedigree and/or indigenous strains of grasses and clovers are very suitable for the successful formation of long leys.

Three series of trials are discussed in this paper; small plots 1/10th acre in size, sown in 1928 (E.86) and in 1929 (E.97), and large demonstration areas, varying in size from one to four acres, sown in 1931 (E.140).

The purpose of these trials was to gain information on the value of simple mixtures containing pedigree and/or indigenous strains over a wide range of soil conditions in Wales and under different systems of management.

The plots were laid down on fields on various farms in the Welsh counties and their management was advisedly entirely in the hands of the farmers concerned. At each centre comparisons were made with ordinary commercial strains of the same species in otherwise similar mixtures and/or with the mixture sown by the farmer himself on the same field.

The main comparisons made in the trials were as follows: indigenous perennial rye-grass[1] with commercial perennial rye-grass; pedigree cocksfoot with Danish cocksfoot; pedigree timothy with ordinary timothy; and pedigree red fescue with Chewing's fescue. The pedigree strains were developed at the Welsh Plant Breeding Station.

For details in regard to the behaviour of the various mixtures in the earlier years of the trials the reader is referred to articles which have already been published (1; 2).

[1] Pedigree perennial rye-grass *ex* Welsh Plant Breeding Station was not included on account of scarcity of seed.

Material and Methods.

Most of the centres were visited during August and/or September, 1936, while on a number of fields detailed analyses were carried out. The practice at most centres was to take a hay crop during the first two or three years and to graze only in later years. At a few centres the fields were grazed from the outset and no hay was taken, whereas at some centres hay was harvested almost every year.

The greater part of the data discussed in previous reports was obtained by the percentage tiller estimation method. In the present report the figures in connection with the 1928 and 1931 trials were obtained by the percentage area method—an estimation method where the total area covered by each species is estimated by eye and calculated as a percentage of the whole.

Counts of tillers per unit area of the chief species and/or strains under test were also made in connection with the 1931 trials. A square mesh 6 inch × 6 inch (inside measurements) was used for the analytical work.

The centres which were sown in 1929 were analysed by the percentage productivity method. Twenty random samples were cut by means of shears on each plot and on a similar sized adjacent area of the farmer's mixture. The herbage was placed in bags and was analysed later in the laboratory.[2]

THE 1928 TRIALS (E.86).

In the spring of 1928 a one-tenth acre strip was sown in fields at approximately ten centres in each of the following counties: Brecon, Radnor, Cardigan, Carmarthen, Merioneth, Montgomery and Pembroke.

Each field was seeded down under a cereal nurse crop—usually barley or oats.

By 1936 (eighth harvest year) several of the plots had been ploughed. A number, however, were still in existence and most of these were analysed in the early autumn of 1936.

All the analyses were carried out by the percentage area method (3).

The Mixtures.

Particulars of the mixtures used are given in Table 1. Mixtures I and III were designed for the better soil types, while Mixture II was used on the more infertile soils.

[2] For further information in regard to the analytical methods, see Davies (3).

TABLE I.

Details of plot mixtures; sown 1928.

Species and strain.	*Mixtures in lb. per acre.*		
	I	*II*	*III*
Italian rye-grass ..	6	6	6
Perennial rye-grass (indigenous) .	14	—	14
Cocksfoot (pedigree)	—	16	—
Rough-stalked meadow grass .	4	4	4
Crested dogstail	4	4	—
Montgomery late-flowering red clover	4	4	4
English wild white clover .	3	3	3

At most farms there was only one plot and therefore it was not possible to compare indigenous perennial rye-grass and pedigree cocksfoot on the same field. Comparisons were made, however, between the plot mixture and the farmer's mixture at most of the centres.

The 1936 (eighth harvest year) data are given in Table II.

TABLE II.

Showing the percentage area covered by various species and strains in 1936 (the eighth harvest year).

Mixtures.	*Perennial rye-grass.*	*Cocksfoot.*	*R'ugh-st'k'd meadow grass and Crested dogstail.*	*Wild white clover.*	*Unsown grasses.*	*Miscellaneous weeds.*
I and III. Indigenous perennial rye-grass	34	—	13	22	16	3
II. Pedigree cocksfoot ...	—	17	14	21	33	2
Farmer's mixture, (Av. of all centres).	13	Trace	12	16	43	3

In Table II the figures for Mixtures I and III are averaged because the plots were similar. Hay was not taken at any of the centres in 1936.

Most of the mixtures used by the farmers contained only a little cocksfoot, whereas they generally contained a large amount of perennial rye-grass. The comparative figures, therefore, are more significant in regard to perennial rye-grass than cocksfoot. Very few of the farmers included rough-stalked meadow grass, crested dogstail and wild white clover in their mixtures. By the eighth harvest year it will be observed that these species had made a considerable unsown appearance.

Reversion by way of ingress of unsown grasses, chiefly *Agrostis* species (bent) and Yorkshire fog, is more pronounced as a result of the sward formed from the farmer's mixture than on the plots.

THE 1929 TRIALS (E.97).

These trials were laid down in a similar manner to the 1928 trials and in the same counties, but two plots were sown at each centre. There were approximately ten centres per county, quite a number of which were still available in 1936. Hay was taken at several centres in 1936.

Botanical analyses were carried out on samples of the herbage cut from the plots in the early autumn of 1936 (seventh harvest year). Estimations by weight were made of the relative amounts of the various species and strains which contributed to the herbage.

A similar sized adjacent area of the farmer's mixture was also sampled and analysed.

TABLE III.

Details of the plot mixtures sown in 1929.

Species and strain.	*Mixtures in lb. per acre.*			
	Ia	*Ib*	*IIa*	*IIb*
Italian rye-grass	6	6	6	6
Perennial rye-grass (indigenous)	—	—	9	9
Cocksfoot (pedigree)	16	—	9	—
Cocksfoot (Danish)	—	16	—	9
Rough-stalked meadow grass	4	4	4	4
Crested dogstail	4	4	—	—
Montgomery late-flowering red clover	4	4	4	4
English wild white clover	3	3	3	3

Particulars of the mixtures used are given in Table III.

The main purpose of the experiment was to test pedigree and commercial cocksfoot in otherwise similar simple mixtures. In Mixtures I*a* and I*b* cocksfoot was sown without perennial rye-grass, whereas in Mixtures II*a* and II*b* indigenous perennial rye-grass was sown with pedigree and commercial cocksfoot respectively.

The data in Table IV represent an average analysis of a number of cut samples taken from the plots at various centres in August to September, 1936 (seventh harvest year). As the analyses were made on cut samples the figures indicate the relative amounts of easily accessible herbage for grazing purposes contributed by the various species and strains.

TABLE IV.

Showing the botanical composition of the plots and the farmer's mixture in the early autumn of 1936 (seventh harvest year).

Mixtures.	*Perennial rye-grass.**	*Cocksfoot.*	*R'ugh-st'k'd meadow grass and Crested dogstail.*	*Wild white clover.*	*Unsown grasses.*	*Miscellaneous weeds.*
I*a* and II*a* (with pedigree cocksfoot)	19	29	8	10	10	9
I*b* and II*b* (with Danish cocksfoot)	24	1	9	15	17	8
Farmer's mixture ...	10	2	11	9	61	10

* Average 7 centres—indigenous perennial rye grass not included in Mixtures I*a* and I*b*.

A succession of hay crops " put up " late and cut late favours pedigree cocksfoot and has a very marked depressing effect on indigenous perennial rye-grass and wild white clover.

The aggression of pedigree cocksfoot in the aftermath was a very striking feature at nearly all centres where it was the practice to take hay almost every year.

Pedigree cocksfoot makes remarkably rapid recovery after hay, and at most centres at the time of sampling the fields had not been grazed since the hay had been removed. It is important, however, to note that the experimental plots occupied only a very small area (1/10th acre) while they were surrounded by the farmer's mixture which occupied the remainder of the field. The farmer's mixture was extremely slow to recover and for this reason, mainly, stock were not turned in to graze for some considerable time after the hay had been removed. By this time pedigree cocksfoot on the plot, although very leafy, had grown beyond its palatable stage.

Fields which contain an abundance of pedigree cocksfoot in the aftermath, therefore, should be grazed early, while the cocksfoot is young and palatable. Indigenous perennial rye-grass, when sown with commercial cocksfoot, did not suffer much because the commercial cocksfoot, being non-persistent, did not contribute in quantity to the hay crop in the later years.

As pasture over a period of years indigenous perennial rye-grass contributed more autumn keep than pedigree cocksfoot even on second class soils. Under pasture management also wild white clover was a significant contributor.

Most of the mixtures used by the farmers themselves did not contain wild white clover nor the bottom grasses—crested dogstail and rough-stalked meadow grass—but these species had made considerable unsown appearance by the seventh harvest year.

Crested dogstail is capable of very successful volunteer establishment on poor soils, and it is very valuable in the later years when sown with commercial strains of perennial rye-grass and cocksfoot which do not persist.

On good soils well supplied with moisture, rough-stalked meadow grass can spread rapidly.

Both rough-stalked meadow grass and dogstail, however, should be included in mixtures on soils that suit them to make certain of their early establishment and because they help to keep out undesirable species during the first few years in the formation of the sward.

THE 1931 TRIALS (E.140).

The 1928 and 1929 trial mixtures were sown as small plots with the farmer's mixture occupying the remainder of the field. In the 1931 trials the commercial plots were small, whereas the mixtures containing the pedigree and indigenous strains covered a large area. In these latter trials the commercial strains in the small plots were sown at the same rate per acre as the pedigree and/or indigenous strains in the large plots.

In the early autumn of 1936 (fifth harvest year) detailed observations were made at most of the centres, while at several centres complete botanical analyses were carried out using the percentage area method (3). Consultations with the farmers concerned in regard to the methods of management adopted were also made.

TABLE V.

Details of the plot mixtures; sown 1931.

Species and strain.	*Mixtures in lb. per acre.*			
	I	*II*	*III*	*IV*
Italian rye-grass	4	4	4	4
Perennial rye-grass (indigenous)	—	8	—	—
Cocksfoot (pedigree)	16	10	10	6
Timothy (pedigree)	4	4	10	12
Red fescue (pedigree)	—	4	—	6
Crested dogstail	4	—	4	—
Montgomery late-flowering red clover	4	4	4	4
Wild white clover	2	2	2	2
Alsike	—	—	—	4

Particulars of the mixtures used are given in Table V.

In the commercial mixtures, Chewing's fescue replaced pedigree red fescue at all centres, while at most centres Dutch white was used instead of wild white clover.

The figures in Table VI represent averages for all the centres examined.

TABLE VI.

Showing (a) the percentage contribution of the various species and strains, and (b) counts of tillers of perennial rye-grass, cocksfoot and timothy per $2\frac{1}{4}$ sq. ft. Average of 9 centres for all species except perennial rye-grass (4 centres) and the fine-leaved fescues (5 centres).

Mixture.	*Species and Strains.*							
	Perennial rye-grass.	*Cocksfoot.*	*Timothy.*	*Fine-leaved fescue.*	*Other sown grasses**	*Wild white clover.*	*Unsown grasses.*	*Miscellaneous weeds.*
Pedigree or indigenous	27	16	Trace	7	12	19	19	5
Commercial	9	3	Trace	19	14	15	40	11

Counts of tillers.

Mixture.	*Perennial rye-grass.*	*Cocksfoot.*	*Timothy.*
Pedigree or indigenous .	268	140	5
Commercial ...	100	22	3

* Mainly dogstail and rough-stalked meadow grass.

Perennial rye-grass and the fine-leaved fescues were not included in all the mixtures.

Figures for volunteer (unsown) perennial rye-grass prevalent in small quantities at some centres where this species was not sown are not included in the average figures.

Discussion of Results.

Indigenous perennial rye-grass and pedigree cocksfoot covered a far higher percentage of ground than their commercial counterparts.

Neither the pedigree nor the commercial strain of timothy showed to advantage at the time the analyses were made.

Chewing's fescue was more aggressive in the commercial mixtures than red fescue was in the pedigree and/or indigenous mixtures. This was due in part to the fact that it was relatively unpalatable and therefore it had every opportunity to spread.

Wild white clover made considerable unsown appearance at some centres. The average figures for the plots, however, in spite of competition with pedigree and/or indigenous strains, were higher than on the commercial strips.

The percentage of unsown grasses was much higher on the commercial strips than on the pedigree plots.

General Conclusions.

The species and strains :

Perennial rye-grass. Indigenous strains were more persistent than commercial strains both as pasture and as hay. Pedigree grazing strains developed at the Welsh Plant Breeding Station have proved better than the indigenous strains discussed in this paper.

In long leys a grass is valuable in proportion to its capability of producing bulk of leafy and palatable herbage over a long grazing season for several years, and it is in this respect that pasture strains of perennial rye-grass have proved their worth. They tiller well and can recover successfully under systems of management which involve severe periodic defoliation. They are able thus, to a considerable degree, to prevent the ingress of unpalatable and less valuable species such as *Agrostis* (bent)—species which provide relatively small quantities of all-through-the-season herbage.

Perennial rye-grass is at its best under conditions of high fertility, but even under poor conditions on soils not liable to suffer from drought the indigenous and pedigree strains can hold the ground well and provide valuable grazing for several years. Perennial rye-grass, especially when sown in mixtures with pedigree cocksfoot, does better under pasture conditions, but it is capable of producing heavy hay crops on good land.

Cocksfoot. Pedigree cocksfoot was more productive than indigenous perennial rye-grass as hay over a period of years on infertile soils. In mixtures, however, it does not establish itself well until the second year. On thin dry soils it persisted well as pasture, but on good soils it suffered when in competition with indigenous perennial rye-grass. During dry summers, pedigree cocksfoot remained green longer than indigenous rye-grass on most soils. For this reason pedigree cocksfoot is very valuable as feed during periods of drought on soils which are likely to suffer in this respect. Commercial cocksfoot persisted fairly well when successive hay crops were taken, but under grazing conditions it soon gave way to inferior species.

Competition between cocksfoot and perennial rye-grass when both species were sown in the same mixtures.

Several of the plots in these trials contained indigenous perennial rye-grass and pedigree cocksfoot as constituents of the same mixture. The "control" plots, where sown, contained commercial strains of these species at the same rate per acre. The farmer's mixtures contained commercial perennial rye-grass at the rate of 10 to 18 lb. per acre and commercial cocksfoot at the rate of 2 to 6 lb. per acre.

In the first and second harvest years the commercial strains were highly productive both as hay and pasture. During later years when both the commercial rye-grass and the commercial cocksfoot were making very meagre contribution to the herbage on account of their lack of persistence, competition between them was not very pronounced. However, where indigenous perennial rye-grass and pedigree cocksfoot were sown together, interspecific competition continued for several years.

It was the practice on some fields to take hay almost every year. These fields, in many cases, were grazed closely until late in the spring and the hay crops were cut late. Under this system of management cocksfoot benefits and perennial rye-grass suffers (4). This is a still more prominent feature where the aftermath is allowed to grow unchecked until the autumn before stock are turned in to graze.

Where the spring grazing was more lenient and the hay crop was cut early, perennial rye-grass did not suffer, and it contributed well to the hay crop. The dominance of cocksfoot following successive hay crops was more marked on the less fertile soils than on good soils.

At most centres no hay was taken after the first two or three years. Under this system of management perennial rye-grass competed successfully with cocksfoot in the later years, even on the poorer soils. On the more fertile fields, perennial rye-grass was aggressive relative to cocksfoot under pasture conditions. Methods of management and differences in degree of fertility, therefore, are important factors in regard to sward dominance by cocksfoot or perennial rye-grass when both are included in the same mixture.

Timothy. In the mixtures under review, neither strain of timothy persisted well. When sown in mixtures at comparatively light seed rates per acre on average soils timothy is not a good competitor. On heavy land and on peat timothy establishes well, and the pedigree strains persist under hard grazing conditions.

For such conditions pedigree timothy should be sown as the dominant grass and at a generous seed rate per acre.

Rough-stalked meadow grass. Ample surface moisture to assist its stoloniferous habit is definitely necessary for this species to be at its best. On dry, thin soils even in such a wet season as the summer of 1936 it did not thrive. On the more fertile soils it was a very successful competitor, and on some of the heavier soils it made a fair contribution to the hay crop. Where pedigree and indigenous strains of perennial rye-grass and cocksfoot are used in mixtures - strains which tiller very strongly—the absence of rough-stalked meadow grass is not such an important factor as they themselves are very efficient in preventing the ingress of weeds. Its inclusion in mixtures is valuable to assist in keeping out weeds until such time as the indigenous strains are well established. In later years on soils that suit it this species is capable of making considerable unsown appearance. It is winter-green and is best suited to grazing conditions. On dry soils crested dogstail should be substituted for it

Crested dogstail is not so sensitive to changes of soil and climatic conditions as rough-stalked meadow grass and it establishes very well from sown seed on a variety of soils. It is extremely valuable on upland thin soils where it contributes well to the second and third hay crops. The leaves are palatable but when the grazing is light it tends to run to head, producing tough and wiry stems. When in this condition it is necessary to use the mowing machine to cut off the stems. It is more aggressive in dry seasons than in wet seasons because it resists drought very successfully, and therefore when it is sown in conjunction with species which are susceptible to the vagaries of the weather it has a particular value on dry land.

Pedigree red fescue. This strain is slow to establish from seed and on most soils it does not make any significant appearance, when sown in mixtures, until the second or third harvest year. When sown at a heavy seed rate per acre it is apt to become very aggressive. Unfortunately it tends, when once well established, to have a detrimental effect on the spread of wild white clover, especially on the less fertile soils.

Under good soil conditions and when sown at a light seed rate per acre, it blends well and, under good management, it does not assume a dominant position.

Its chief use, however, is in connection with the seeding down of dry, exposed upland fields where it acts as an excellent weed

suppressor. If grazed closely it remains remarkably winter-green.

When it is included in mixtures it should be sown at a light seed rate per acre—1½ to 2 lb.

Chewing's fescue was more aggressive than red fescue in the trials under review. It was relatively unpalatable and this was a prominent feature at centres where it assumed a dominating position. It becomes badly winter burned.

Red fescue should be used instead of Chewing's fescue in seeds mixtures where either of these strains is considered necessary.

Wild white clover was at its best under pasture conditions. At a number of centres wild white clover made considerable unsown appearance on the commercial plots during the later years but its contribution was higher on the plots on which it had been sown. The presence of wild white clover has a valuable effect on the other species forming the sward, and it also has an important effect on the feeding value of the herbage as a whole.

Wild white clover should, therefore, be included in all mixtures for long leys and permanent grass.

It is impossible to submit a scheme of management to suit all purposes. Modifications in certain directions, however, are well worth the farmer's attention.

If fields are put up to hay, every effort should be made to close them not later than the middle of April and the hay should be cut early in June. The hay should then be leafy and highly nutritious.

The aftermath should always be grazed while it is young and succulent and therefore stock should be turned in as soon as herbage is available after the hay crop has been removed. Severe and continuous spring grazing affects the recovery of the species grazed, whereas intermittent spring grazing helps to improve the sward.

Fields which contain bent should be well grazed during mid season when this grass is in active growth.

In practice it is difficult to adhere to a strict code of rules in regard to management, especially on upland fields. The knowledgable use of temporary crops for winter and spring grazing, however, will help to solve a number of problems that confront the farmer.

Italian rye-grass, rape, hardy green turnips and kale are useful for this purpose.

Summary.

1. The comparative value of pedigree, indigenous and commercial strains of grasses has been discussed.

2. Indigenous perennial rye-grass and pedigree cocksfoot have been more persistent as pasture and have produced more hay over a period of years than their commercial counterparts.

3. When leafy persistent strains of perennial rye-grass and cocksfoot are sown together, one or the other will usually be favoured by subsequent management and by soil conditions. Thus cocksfoot will tend to predominate where hay is taken every year and particularly when that is followed by lenient autumn grazing. On the other hand where the grazing rotation is properly planned perennial rye-grass will be the aggressor on good soils, while on soils of lower fertility cocksfoot may supersede it.

4. Timothy on average soils is not a good competitor when it is sown in conjunction with heavier seedings of perennial rye-grass and cocksfoot. On heavy and peaty soils pedigree timothy establishes successfully and can withstand severe grazing for several years. It should always be sown at a generous seed rate per acre.

5. Pedigree red fescue is valuable on exposed infertile upland soils. Under good management it blends well in mixtures on fertile soils and it remains winter-green. Chewing's fescue is unpalatable and becomes badly winter-burned even if it is reasonably well grazed.

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HETEROSIS IN RED CLOVER.

EFFECT OF IN-BREEDING IN F_2 AND F_3 POPULATIONS.

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The writer since 1925 has conducted a series of investigations with the object of studying the effect of in-breeding on the fertility and vigour of growth in red clover. The results of some of the earlier experiments, extending from 1925 to 1930, are reported in this paper. The findings of the more recent investigations, many of which are still in progress, will be published at a later date.

The phenomenon of heterosis, apart altogether from its great theoretical interest, has a very important practical bearing, as the methods and technique employed in the improvement of cross-fertilized crops must necessarily depend on the extent, if any, of the reduction in fertility and vigour of growth which occurs as a result of in-breeding.

Red clover is an entomophilous cross-fertilized crop. The great majority of the plants are completely self-sterile, but occasionally a few " pseudo—self-fertile " seeds are produced as a result of the union of gametes carrying like sterility factors. Genuinely self-fertile plants carrying self-fertile factor " *Sf* " are of very rare occurrence in red clover; out of many thousands of plants the writer has only found one plant of this type. The system of in-breeding adopted throughout the investigations reported in this paper was brother-sister matings.

During the last thirty years a great deal of attention has been devoted to the problem of heterosis in plants. This phenomenon has been found to occur in widely separated naturally cross-fertilized crops, and has been extensively studied in maize (Shull 1910; East and Hayes 1912; Emerson and East 1913; Jones 1917; East and Jones 1920, *et al.*); lucerne (Kirk 1927 and Torssell 1930); red clover (Kirk 1925); sugar beet (Stewart 1933); egg plant (Kakizaki 1931): crucifers (Rasmusson

1932); perennial rye-grass (Jenkin 1927); timothy grass (Clarke 1927, Valle 1931, Nilsson 1934); cocksfoot (Stapledon 1931, Nilsson 1934), and in many other species.

Though our knowledge of the precise mechanism of the processes involved is still meagre, the interpretation of heterosis proposed by Jones (1918 and 1917) is now generally adopted by most geneticists, at least as a tentative working hypothesis. On this hypothesis the loss of vigour of growth resulting from in-breeding and the increased vigour resulting from hybridization are due to the segregation and re-combination of numerous favourable dominant and unfavourable recessive factors affecting growth, many of which are presumably more or less closely linked. The first generation plants carry all the favourable dominant factors of both parents, and are on that account more vigorous than either parent. As the large majority of the plants in the second generation will contain fewer favourable factors than the first generation, the in-bred progeny will be, on the average, less vigorous than the cross-breds.

Material and Methods.

Most of the data presented in this paper were obtained from two experiments, designated A.110 (25) and A.110 (28), which were conducted for the express purpose of investigating the effect of in-breeding on vigour in red clover. In addition to the data from these two experiments a considerable amount of information bearing on this problem has also been secured from pedigree cultures used in connection with economic breeding.

The parent plants used in the A.110 (25) experiment were obtained from six totally unrelated F_1 families derived from Montgomery red clover. Two cross-compatible sister plants from each family were arranged, for the purpose of crossing, in three groups each consisting of two pairs of sibs. The four plants constituting each group were reciprocally cross-pollinated according to the scheme illustrated below to produce two F_1 and two F_2 families. By this arrangement both the F_1 and F_2 progenies of each group were derived from the same parent plants.

	(= F_2)	
[1] 93 (1) 12	×	93 (1) 16
× - (F_1)		× - (F_1)
99 (1) 48	×	99 (1) 73
	(= F_2)	

[1] According to the nomenclature employed at this Station the bracketed numeral (1) indicates the generation, which in this instance is F_1: the prefix —93—indicates the reference number of the family and the suffix—12—is the reference number of the actual plant crossed.

The seeds of 12 F_1 and 12 F_2 progenies obtained in this way were sown in sterilized soil; the seedlings were transplanted into the field in June, 1926, when about four to five inches in height.[2] Two hundred seedlings of each population were planted in randomised plots consisting of five rows of ten plants each; spacing was ample for full development, being twenty-four inches between the rows and twenty inches between each individual. Each group consisting of two F_1 families with the corresponding two F_2 families was allocated separate, though adjoining, experimental blocks.

Towards the end of the autumn of the first year after active growth had practically ceased the plants were evenly cut back, but no comparative weights were taken in that year. In the second year, each plant was cut and weighed twice during the growing season; the first of these cuttings was taken on July 11th, when most of the plants were in the early bloom stage, and the second was made on September 26th, when the plants had almost completed growth for the season.

In the A.110 (28) investigations, vigour of growth of two F_2 and three F_3 populations was compared with that of F_1 populations. In this case a somewhat different method of approach was adopted. The sibs used were taken from two F_1 and F_2 families included in the A.110 (25) experiment. Two cross-compatible sister plants of each family were reciprocally cross-pollinated, and each was also crossed with another plant of a totally different origin. The same two plants, designated below "A" and "B," were used for all the out-crosses. The mating scheme employed is shown below:—

Sibs	216(1) 1 ×	216(1) 18	99(2) 129 ×	99(2) 188
	×	×	×	×
Unrelated plants	A	B	A	B

Each group consisting of two F_1 progenies, together with the corresponding in-bred progeny, was planted in adjoining experimental blocks. The seedlings were planted out on June 15th, 1929, in single rows of ten plants each. The number of replications per family ranged from fifteen to twenty-five rows,

[2] All the seedlings planted in the field were perfectly normal. Two in-bred families, one F_2 family in A.110 (25) and one F_1 family in A.110 (28), segregated on a 3:1 basis for a recessive chlorophyll-deficient type. The seedlings of this particular type were quite distinctive: they were much smaller than normal green seedlings: the cotyledon, simple and first few trifoliate leaves formed were almost completely covered with a fairly coarse, yellowish-green variegation. In the adult plants only a few of the leaves were variegated, most being practically a normal green. All seedlings of this type were planted separately and will not be considered in this report.

according to the number of seedlings available in the smallest family of each group. Since red clover does not attain to full development until the second year, no weights were taken in the first year. In the second year each row was cut and weighed separately, twice; the first cut was taken on June 30th and the second on September 24th.

Effect of In-breeding on Fertility.

The data relating to the effect of in-breeding on the cross-fertility of red clover obtained during the years 1925-30, including those obtained from A.110 (25) and A.110 (28), have already been published (Williams, 1931). These results indicated that in-breeding has no inherent effect on the fertility of red clover.

Since these results were published further data bearing on this problem have been obtained incidentally from various crosses made in connection with genetical investigations and practical breeding, and these are briefly summarized below.

Plants crossed.	*No. of crosses.*	*No. of florets pollinated.*	*Average percentage no. of seeds.*	*Value of t*	*Approximate value of P.*
F_1 out-crossed	50	12,883	58.26	0.1179	0.9
$F_1 \times F_1$	50	15,346	58.76		
F_2 out-crossed	4	1,059	64.15	0.1702	0.8 – 0.9
$F_2 \times F_2$	4	805	61.73		

These results are strictly comparable as in all cases the out-bred and in-bred seeds were produced on the same plants which had been cross- and in-pollinated by hand at about the same time. A number of the brother-sister matings were completely cross-incompatible,[3] and consequently produced no seed. The data from all incompatible crosses have been omitted.

It will be seen from a comparison of the figures given above that, if the incompatible matings are excluded, the $F_1 \times F_1$ pollinations were on the average quite as effective as the out-crosses. The mean fertility of fifty F_1 brother-sister matings was 58.76 per cent., while the average fertility of the same plants when out-crossed was 58.26 per cent. The $F_2 \times F_2$ matings gave on the average slightly fewer seeds per 100 florets pollinated than the corresponding out-pollinations. It is, however, quite evident, as shown by the computed value of P, that the small

[3] Cross-incompatibility in red clover is known to be due to a series of sterility allelomorphs acting as oppositional factors. Plants carrying like sterility factors are cross-incompatible while those with unlike sterility factors are cross-fertile (*vide* Williams and Silow, 1933).

difference of 2.68 per cent. in favour of the out-crosses is not statistically significant.

It will be interesting at this juncture to compare the figures presented above with the published results obtained prior to 1930 relating to the same problem. To facilitate comparison some of the published data are appended below :—

Year.	*Type of cross.*	*No. of cross.*	*Average percentage no. of seeds.*	*Difference of "out" cross over "in" cross.*	*Odds*
1925	F_1 out	11	60.8	— 3.4	3 : 1
	$F_1 \times F_1$	11	64.2		
1928	F_1 out	11	64.1	+ 9.1	6 : 1
	$F_1 \times F_1$	11	55.0		
	F_1 out	6	69.1	+11.8	11 · 1
	$F_2 \times F_2$	6	57.1		
	F_1 out	2	70.5	— 1.2	1 : 1
	$F_3 \times F_3$	2	71.7		
1929	F_1 out	18	40.3	— 1.0	1 : 1
	$F_2 \times F_2$	18	41.3		
	F_1 out	6	43.1	—11.1	5 : 1
	$F_2 \times F_2$	6	54.2		

All the cross-incompatible matings have been omitted from the above results. The two sets of data—those secured prior to 1930 and those obtained since that year— are in close agreement in that the differences between the average fertility of the out-crosses and the corresponding sib crosses did not in a single case exceed the limits due to chance.

It is therefore evident that in the case of red clover in-breeding has no apparent effect on the fertility of cross-compatible plants.

Viability and Energy of Germination of In-bred Seeds.

During the course of experiment A.110, and other investigations, forty-nine first generation plants, fifteen second generation and eight third generation plants were pollinated by compatible sibs as well as by unrelated plants. The seeds obtained from these crosses formed suitable material for investigating the effect of in-breeding on germination. The out-bred and in-bred seeds from each plant were sown under as uniform conditions as possible. Usually they were planted on the same day in greenhouses and in sterilized soil and covered to a depth of about a quarter of an inch. Before sowing they were carefully rubbed with sand-paper, as hard seeds treated in this way germinate quite readily. The energy of germination is based on the number of seedlings which had emerged through the soil on the twelfth

day after sowing; usually they started breaking through in about seven to ten days. The comparison of the viability of the seeds is based on the final counts which were made about thirty days after sowing.

In all cases the observations were restricted to a comparison of the performance of the out-bred and in-bred seeds of the same maternal origin, and the data thus obtained were analysed statistically by the "Student's" paired method. The figures relating to viability of the seeds are given in Table I.

TABLE I.

Comparison of the viability of cross-bred and in-bred seeds of the same maternal parentage.

Progeny.	*No. of crosses.*	*No. of seeds sown.*	*Average percentage germination.*	*Difference between cross-breds and in-breds.*	*Value of t*	*Value of P.*
F_1	49	8,108	78.4	+2.9	1.1128	0.1 -0.2
F_2	49	9,161	75.5			
F_1	15	2,824	80.8	+0.1	0.0214	0.9
F_3	15	2,205	80.7			
F_1	8	1,394	78.2	+0.9	0.1018	0.9
F_4	8	1,430	77.3			

The cross-bred seeds germinated on the average very slightly better than the corresponding in-bred seeds. The mean percentage germinations of F_1 and F_2 seeds of the same mother plants were 78.4 and 75.5 respectively—a difference of 2.9 per cent. in favour of the cross-breds. It is clear from the value of P. which in this case lies between 0.1 and 0.2, that a difference of this order may occur once in about seven trials, and therefore cannot be regarded as significant. The mean percentage germinations of the comparable F_1 and F_3 seeds were almost identical, while the mean germination of the F_1 and F_4 seeds were 78.2 and 77.3 per cent. respectively. As shown by the value of P. the odds are very high that the small difference of 0.09 per cent. between the germination of the F_1 and F_4 seeds was due to chance fluctuations. It is evident, therefore, from these results that the viability of F_2, F_3 and F_4 seeds was not in any way affected by in-breeding.

Since there are no comparable data for cross-fertilized seeds, the germination results of F_5 seeds have not been included in **Table II.** Nevertheless the results—543 seeds of eight crosses gave a mean germination of 95.9 per cent.—are very interesting,

as they demonstrate that the viability of the seeds had not been depressed even after five successive generations of close breeding.

The observations on the energy of germination were made on twelve lots of out-bred and in-bred seeds derived from the same mother plants. These are shown below :—

	No. of seeds	*Mean percentage germination twelve days after sowing.*
Cross-bred seeds	2,393	97.4
F seeds	1,807	95.8

It is clear from these figures that the germination energy of the F_2 seeds had not been reduced as a result of in-breeding.

Rate of Growth of In-bred Seedlings.

In order to ascertain whether the rate of development of seedlings, as expressed by their height, was reduced as a result of in-breeding, the seedlings of a number of cross-bred and in-bred progenies of the same maternal origin were measured on the sixty-first day after sowing. For this purpose eleven pairs of F_1 and F_2 progenies and eight pairs of F_1 and F_3 progenies were taken, and thirty seedlings from each cross were measured from ground level to the tip of the longest leaf while still in the seedling boxes. The seeds were sown early in February, and in consequence their rate of growth during the first two months or so was very much slower than if they had been sown late in the spring. The results of the measurements, calculated by the paired method, are given below :--

Progeny	*No of crosses*	*Mean height (cm.)*	*Gain of cross breds over in-breds (cm.)*	*Value of P*
F_1	11	8.41	1.36	0.02–0.01
F_2	11	7.05		
F_1	8	8.51	2.11	0.01
F_3	8	6.41		

These results show that on the average the F_1 seedlings were 1.36 cm. taller than the F_2 seedlings, and 2.11 cm. taller than the F_3 seedlings. Expressed as percentage the cross-breds gave 18.6 per cent. increase in height over the F_2 progenies and 38.4 per cent. increase over the F_3 progenies. As is shown by the computed values of P, the odds were very high against these differences being due to chance.

It may be stated as a general observation based on the examination of a very large number of families that in-bred

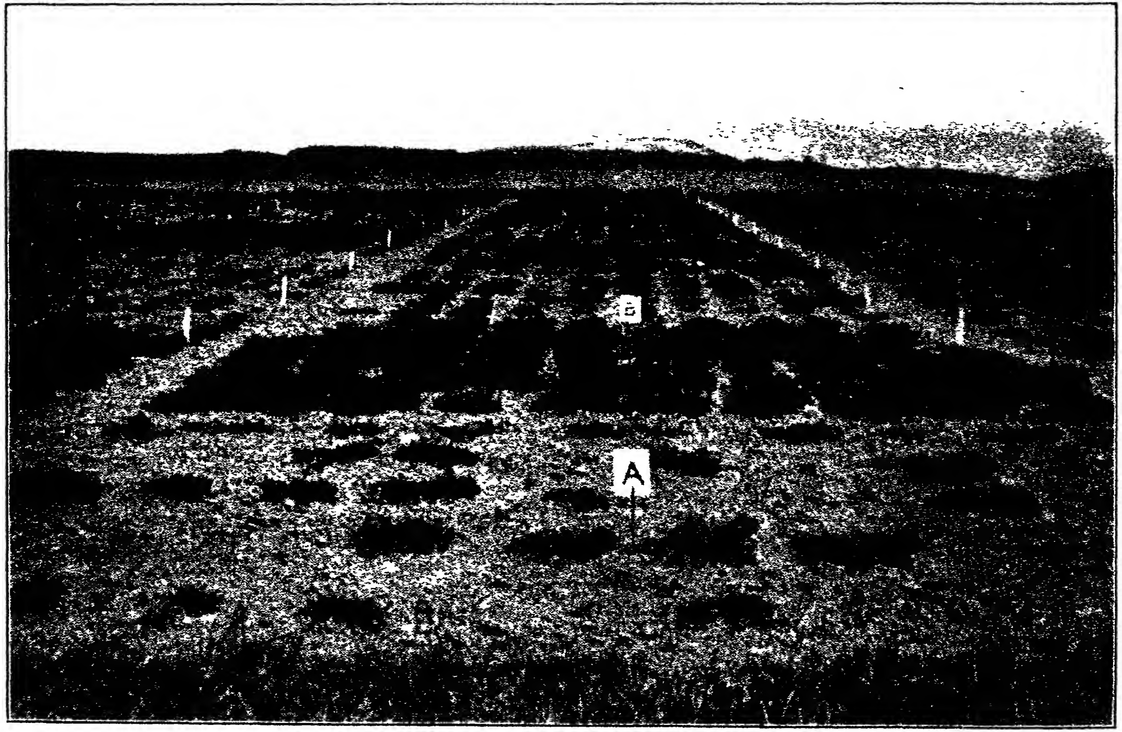

FIG. 1.

Showing the effect of inbreeding on growth in the autumn of the first year. Group A: first generation population. Group B: second generation population.

progenies are on the average invariably weaker in the seedling stage than cross-fertilized progenies. Usually during the first two weeks or so there is no visible difference between the seedlings; the lack of vigour of the in-bred families generally becomes visible to the eye in the third or fourth week after germination, and by the sixth week the difference in vigour of growth, as reflected in the number and size of the leaves, and in plant height, is usually very marked. The greater vigour of the cross-fertilized populations during the early stages becomes still more pronounced after the seedlings have been transplanted. The increased vigour of the F_1 as compared with the F_2 populations in the late seedling stage is clearly brought out in Fig. 1. In this photograph, which was taken in September of the first year, the plant group A is an F_1 population, while group B is an F_2 population of the same parentage as the F_1.

Mortality among In-bred Progenies.

The A.110 (25) and A.110 (28) seedlings were transplanted when about four to six inches in height. At this stage the seedlings of even the in-bred progenies had strong and well developed root systems, and in consequence there were only very few casualties as a result of transplanting. The few seedlings that did perish were replaced within three weeks.

In order to compare the mortality in the cross-bred and inbred populations the number of casualties in each family were recorded at different times during the three years the plants were under observation. The results based on some of these observations are presented in Table II.

TABLE II.

The rates of mortality in F_1, F_2 and F_3 populations in A.110 (25) and A.110 (28) experiments.

Experiment.	*Generation.*	*Number of Progenies.*	*Number of Seedlings Planted.*	*Percentage Mortality.* First Yr				Third Year.	
					Second Year.			*Third Year.*	
				Sept.	*April*	*July.*	*Sept.*	*May.*	*July.*
A. 110 (25)	F_2	6	1,150	4.4	14.3	14.7	25.3	68.4	70.9
	F_1	6	1,200	3.0	6.8	7.6	18.5	58.9	59.8
A. 110 (28)	F_2	2	240	9.6	22.1	25.0	54.6	85.8	—
	F_1	2	400	8.0	9.8	11.0	39.8	69.8	—
	F_3	6	490	17.2	21.4	22.7	53.1	71.0	—
	F_1	6	980	3.0	4.2	4.2	22.8	56.8	—

Throughout the three years during which the A.110 plants were kept under observation the mortality rates in the cross-bred populations were on the average considerably lower than in the

case of the in-bred populations. The difference between the F_1 and F_2 progenies in this respect was not very pronounced during the first year, but became much more marked in the second and third years. In A.110 (25), by the end of September of the first year only 8.0 per cent. of the F_1 and 4.4 per cent. of the F_2 plants had perished. From September to April in the second year as many as 14.7 per cent. of F_2 plants had died, as compared with only 6.8 per cent. of the cross-fertilized plants. During the second winter the casualties in both F_1 and F_2 populations were heavy, but were more severe in the in-bred material. The A.110 (28) data indicate not only that the F_2 plants were on the average less persistent than the cross-fertilized plants, but also that the F_3 plants were, on the whole, appreciably shorter lived than the F_2 plants. The casualties among the F_3 plants were exceedingly heavy during the first year. On reference to Table I it will be seen that while there was very little difference between the number of casualties in the F_1 and F_2 progenies in September of the first

TABLE III.

Comparison of the longevity of various cross-bred and in-bred populations. The data were secured from crosses made in connection with economic breeding.

Planting Year.	*Parent Variety.*	*Generation*	*Number of Crosses.*	*Number of Seedlings Planted*	*Mean Percentage Mortality* — *Second Year* — *May*	*Second Year* — *September*	*Third Year* — *June*
1930	Montgomery.	F_2	20	1,214	7.4	--	36.5
		F_1	18	1,387	2.4	--	28.4
1931	Wild X... Montgomery	F_2	14	620	8.7	16.3	19.2
		F_1	10	530	2.6	1.4	8.9
	Montgomery	F_3	3	123	9.8	26.1	61.0
		F_2	19	900	3.8	15.2	25.8
		F_1	73	3,623	2.1	9.3	17.1
1932	Wild X .. Montgomery.	F_2	11	630	3.0	13.5	30.7
		F_1	16	581	6.0	10.4	31.5
	Montgomery.	F_3	3	140	3.5	11.1	59.3
		F_2	11	630	4.0	10.3	30.6
		F_1	87	4,832	3.0	9.8	27.7
	Broad Red	F_3	8	270	22.6	39.3	87.4
		F_2	4	210	8.6	27.6	87.6
		F_1	19	994	6.0	29.0	84.3
1933	Wild X... Montgomery.	F_2	38	1,246	3.6	20.8	88.4
		F_1	24	909	2.7	14.4	58.7
	Montgomery.	F_3	15	620	6.0	20.3	87.4
		F_2	100	3,952	6.0	31.9	85.6
		F_1	50	2,100	1.5	18.6	64.7

year, the number of dead plants in the F_3 progenies was nearly six times that in the corresponding cross-bred families.

A great deal of information relative to the effect of in-breeding on the longevity of red clover has been collected from sources other than the A.110 experiments, more particularly from material used in connection with practical breeding. The results obtained from these sources are not strictly comparable, since the cross-bred and in-bred populations were not of the same parentage, but they are fairly reliable, however, because all the progenies which are compared were derived from the same varieties, and were planted on the same experimental ground and subjected to the same treatment.

The data obtained from the economic crosses (Table III) agree in the main with the A.110 results (Table II). Though in-bred progenies of the same varietal origin often show varying degrees of persistence it may be stated that in general the longevity of red clover plants decreases progressively after each successive generation of in-breeding. The first generation plants are, on the average, more persistent than the second generation plants, which in turn are longer lived than the third generation plants.

In-bred progenies originating from the same variety often exhibit striking differences in regard to persistence. For instance, some of the F_2 families derived from Montgomery clover, which is the most persistent red clover variety grown in this country, proved to be exceedingly short-lived with mortality rates of 30 to 40 per cent. for the first twelve months and 100 per cent. for the first two years, while a few F_2 progenies derived from the same variety have proved to be more persistent than the parent variety itself. The extreme variability of in-bred progenies in this respect is brought out by the following figures giving the percentage mortality in the second and third year for a number of in-bred Montgomery red clover families :

Year of planting.	*Generation.*	*Percentage mortality.* *Second year.*	*Third year*
1931	F	0	1.0
	,,	0	12.0
	,,	24.0	52.0
	F	1.7	48.2
	,,	20.0	60.0
1932	F_1	2.5	10.0
	,,	2.5	17.5
	,,	3.3	50.0
	,,	3.3	53.0

Year of planting.	*Generation.*	*Percentage mortality.* Second year.	Third year.
1933	F_3	0.0	18.0
	,,	2.0	16.5
	,,	3.0	15.0
	,,	12.5	100.0
	,,	34.0	100.0
	,,	37.7	100.0

It is not an uncommon occurrence for long-lived parents selected from highly persistent F_1 families to give both long-lived and short-lived F_2 and F_3 progenies. Results of a few of these crosses are shown below :—

Year.	*Family number.*	*Generation.*	*Percentage mortality.* Second year.	Third year
1931	351 (2) 19 × 70	F_2	0	4
	351 (2) 40 × 68		25	55
1933	784 (2) 33 × 44	F_2	0	10
	784 (2) 44 × 54		0	10
	784 (2) 9 × 33		0	100
	781 (2) 5 × 9		4	100
1933	506 (2) 5 × 9	F_2	2	16
	506 (2) 4 × 6		16	100
	506 (2) 4 × 10		34	100
	506 (2) 5 × 10		0	100
1933	230 (3) 132 × 135	F_3	4	10
	230 (3) 12 × 124		0	25
	230 (3) 78 × 124		0	100
	230 (3) 128 × 135		4	100

Productiveness of In-bred Plants.

The yield data obtained from A.110 (25) experiment are summarized in Tables IV and V.

TABLE IV.

Average yield of green fodder (hay and aftermath) produced by F_1 and F_2 plants in the second year in A.110 (25) investigations.

Group.	*Progeny.*	*Parent Plants.*	*Family Number.*	*No. of Plants Weighed.*	*Weight per Plant* Lb	S.E	Percentage productiveness.
1	F_1	93 (1) 12 × 90 (1) 48	215 (1)	175	1.157	.0366	100.0
	F_1	93 (1) 16 × 90 (1) 73	216 (1)	179	0.792	.0326	
	F_2	93 (1) 12 × 93 (1) 16	93 (2) 12 × 16	171	0.484	± .0254	42.9
	F_2	99 (1) 48 × 99 (1) 73	99 (2) 48 × 73	124	0.353	± .0303	
2	F_1	93 (1) 22 × 108 (1) 53	217 (1)	142	0.895	± .0409	100.0
	F_1	93 (1) 27 × 108 (1) 74	218 (1)	180	1.119	± .0491	
	F_2	93 (1) 22 × 93 (1) 27	93 (2) 22 × 27	152	0.886	.0686	76.7
	F_2	108 (1) 53 × 108 (1) 74	108 (2) 53 × 74	164	0.656	± .0413	
3	F_1	95 (1) 17 × 111 (1) 1	219 (1)	153	1.223	± .0486	100.0
	F_1	95 (1) 33 × 111 (1) 11	220 (1)	149	1.118	± .0496	
	F_2	95 (1) 17 × 95 (1) 33	95 (2) 17 × 33	121	0.682	± .0431	62.8
	F_2	111 (1) 1 × 111 (1) 11	111 (1) 1 × 11	136	0.785	± .0411	

The weights given in Table IV represent for each family the average total yield per plant of green fodder produced as hay and aftermath in the second year. As previously stated, 200 seedlings of each family were planted. As a number of these plants

TABLE V.

Distribution of weights per plant of the F_1 and F_2 populations in first cut of A.110(25).

Group.	Progeny.	Family Number.	Class Centres (gm.). 50	150	250	350	450	550	650	750	850	950	1050	1150	1250	1350	Total Plants	Means (gm.)	S.E.	Coef. of var.	S.E.
1	F_1	215 (1)	5	11	17	29	42	32	25	24	5	3	3				196	446.42	± 14.71	46.01	± 2.33
		216 (1)	20	34	38	39	30	9	5	2	2						179	502.52	± 12.58	55.62	± 2.93
	F_2	93 (2) 12 × 16	49	58	20	18	11	6									171	197.13	± 10.49	70.23	± 3.76
		99 (2) 48 × 73	34	25	25	11	9	1	1								109	205.96	± 14.25	71.89	± 4.89
2	F_1	217 (1)	9	20	28	32	32	14	13	5	1	1	1	1	1		158	387.31	± 16.64	53.86	± 3.01
		218 (1)	9	15	32	29	24	21	22	15	10	4	2	3	1	1	188	471.47	± 19.18	55.27	± 2.86
	F_2	93 (2) 22 × 27	9	17	39	36	33	19	11	5	2	3					174	379.89	± 14.34	49.63	± 2.67
		108 (2) 53 × 71	44	40	22	29	15	9	7	6				1			173	264.45	± 15.61	77.86	± 4.20
3	F_1	219 (1) . . .	7	16	16	24	21	27	29	12	16	10	1	2	5		186	537.63	± 20.26	51.07	± 2.65
		220 (1) . . .	22	11	15	23	36	16	25	20	6	3	7	4	1	1	190	491.05	± 20.85	58.39	± 3.00
	F_2	95 (2) 17 × 33	32	40	30	24	12	15	6	4	4	2	2				171	300.88	± 17.56	76.12	± 4.13
		111 (2) 1 × 11	23	21	23	30	17	16	5	9	3						147	237.07	± 17.37	62.23	± 3.64

perished before the last cut was taken only the weights of those which contributed both hay and aftermath are included in Table IV. As may be seen from reference to the Table, within each

group the two F_1 populations, taken separately and collectively, were more productive than the F_2 populations of the same parentage. If the aggregate yields of F_1 and F_2 plants within each group are compared on a percentage basis it will be seen that the productivity of the F_2 plants in Group 1 was only 42.9 per cent., in group 2 only 76.7 per cent., and in Group 3 only 62.8 per cent. of that of the cross-fertilized plants. With the exception of the F_2 family, 93 (2) 22 × 27 in Group 2, which was nearly as productive as one of the F_1 families—217 (1)—in the same group, mean plant yields of all the F_2 progenies were very significantly lower than those of the corresponding F_1 progenies, as the differences between the weights of F_1 and F_2 plants are in all instances more than three times their standard errors.

The frequency distributions of the weights per plant in the first cut are given in Table V. It will be seen from this table that the productivity of the individual plants within each population varied within very wide limits. As shown by the co-efficients of variation, the F_2 populations, with the exception of family 93 (2) 22 × 27, were definitely more variable than the corresponding cross-bred populations. This is in accordance with expectation, as many of the unfavourable recessive growth factors which were more or less masked by favourable dominant factors in the F_1 generation have segregated out in the F_2 generation, so that at least some of the F_2 plants were carrying a number of deleterious growth factors in the homozygous condition.

It will be observed from Table V that although all the F_2 progenies contain a small number of very high yielding individuals, in every instance the most vigorous plants in the F_2 populations were less productive than the heaviest yielding individuals in the corresponding cross-bred populations. Again this is in conformity with hypothesis, as it is extremely improbable in view of the comparatively small number of plants involved that any of the second generation individuals would be carrying all the favourable growth factors present in the F_1 parent plants.

In the main the weight distributions of the first generation plants conform fairly closely to a somewhat flattened normal variability curve, but one of the cross-bred progenies, namely, 220 (1), gave a frequency curve which rather suggested a multimodal distribution. On the other hand, all the F_2 populations gave skew distributions due to a preponderance of weak and low yielding individuals.

The yields in the second cut were very much smaller than in the first cut, but the distributions of the plant weights of the different populations agree fairly closely with those shown for the first cut.

TABLE VI.

Average yield of green fodder (hay plus aftermath) produced by F_1, F_1 and F_2 progenies in the second year in A.110(28) investigation.

Group.	Progeny	Parents Crossed	Family Number	No of Rows.	Yields. Per Row. lb.	Per Row. S.E.	Per Row percentage.	Per Plant alive when weighed lb.	Per Plant alive when weighed Percentage.
4	F_1	218(1)11 × A	511(1)	18	17.07	± 0.719	100.0	1.872	100.0
	F_1	218(1)158 × B	512(1)	18	13.69	± 1.071		1.703	
	F_2	218(1)11 × 218(1)158	218(2)11 × 158	18	11.61	± 0.664	75.7	1.298	72.6
5	F_1	216(1)1 × A	505(1)	12	14.27	± 0.427	100.0	1.470	100.0
	F_1	216(1)68 × B	506(1)	12	14.56	± 0.613		1.613	
	F_2	216(1)1 × 216(1)68	216(2)1 × 68	12	7.72	± 0.499	53.5	0.858	55.6
6	F_1	93(2)42 × A	507(1)	11	11.45	± 1.187	100.0	1.528	100.0
	F_1	93(2)18 × B	508(1)	11	15.72	± 1.089		1.657	
	F_2	93(2)42 × 93(2)18	93(3)42 × 18	11	7.35	± 1.030	48.7	0.981	61.6
7	F_1	108(2)28 × A	509(1)	20	13.46	± 0.363	100.0	1.448	100.0
	F_1	108(2)178 × B	510(1)	20	14.61	± 0.524		1.529	
	F_2	108(2)28 × 108(2)178	108(3)28 × 178	20	5.19	± 0.393	36.9	0.799	53.7
8	F_1	99(2)129 × A	497(1)	13	10.27	± 1.245	100.0	1.041	100.0
	F_1	99(2)188 × B	498(1)	13	11.13	± 1.371		1.610	
	F_2	99(2)129 × 99(2)188	99(3)129 × 188	13	3.54	± 0.710	29.0	0.599	45.2

In the A.110(28) investigations, the results of which are recorded in Table VI, the productivity of F_1 as well as F_2

progenies was compared with that of F_1 progenies. As stated earlier in this paper, in this experiment the seedlings were planted in rows of ten each at only twelve inches apart. As it was practically impossible to separate the individual plants, each row was cut and weighed as a self-contained unit. The plants were cut twice in the second year and the yields obtained are expressed in Table VI, column 5, in terms of lb. of green fodder per row. and in column 7 as lb. of green fodder per plant. The latter figures were secured by simply dividing the weight of the total produce of each progeny by the number of plants alive when the rows were cut.

If the weights per row in Table VI are compared it will be seen that the F_1 progenies were considerably more productive than their F_2 and F_3 counterparts. Expressing the yields per row as percentages, the productivity of the F_2 family in group 4 was 75.7 per cent., and in group 5, 53.5 per cent. of that of the F_1 progenies, while the yield of the F_3 family in group 6 was only 48.7 per cent., in group 7 only 30.9 per cent., and in group 8 only 27.0 per cent. of that of the corresponding F_1 families.

It will be observed that the diminution in productivity was much more pronounced in F_3 generations than in F_2. Average yields of the two F_2 progenies were 64.6 per cent. of the F_1 plants, while the mean yield of the three F_3 progenies was only 38.2 per cent. of the F_1 plants.

If the results are expressed in terms of yield per plant actually weighed, instead of yield per row, owing to the low rate of mortality of the F_2 progenies the reduction in yield in the F_3 generation, though still very marked, is not quite so pronounced. Calculated on this basis, the mean weight of the F_2 plants was 68.6 per cent., and of the F_3 plants 53.5 per cent. that of cross-fertilized plants.

A considerable mass of data demonstrating the loss of vigour which follows in-breeding has been secured from various economic crosses. All the data obtained from this source, some of which are discussed below, are in general agreement with the results of A.110 experiments.

The following figures give the mean weight of green fodder produced by twenty-five F_1 and twenty-four F_2 populations planted in 1929 at the same time and on the same area, and cut on the same day in 1930. All these progenies were derived from different Montgomery parents. As the families consisted of varying numbers of plants the yields are expressed as the mean weight per plant per progeny.

Generation.	*Number of Progenies.*	*Number of Seedlings Planted.*	*Yield per individual planted. (lb.)*	*Yield per individual weighed. (lb.)*
F_1	25	2641	0.716 ± 0.044 (100)	0.775 ± 0.040 (100)
F_2	24	2944	0.442 ± 0.077 (61.7)	0.573 ± 0.037 (73.9)

If the results obtained are compared on the basis of the number of seedlings planted, F_2 yields show a reduction of 38.3 per cent. as compared with those of F_1 plants; but if the higher mortality rate of the in-bred plants is ignored and results are compared on the basis of the number of individuals alive when the plants were weighed, the reduction in yield of the F_2 plants is 26.1 per cent.

Different in-bred progenies of the same generations and ancestry generally exhibit wide variation in regard to their vigour of growth. The results considered below may be regarded as representing a larger body of other data of a similar character.

The first results considered were obtained from three sister F_2 progenies derived from the same F_1 family—381 (1) of English broad red parentage. The seedlings of each progeny were planted in five replicated lines each consisting of twenty plants six inches apart. The plants were cut in the second year on the same day when they were nearly in full bloom. The average yields in lb. of green produce per line are as follows:—

	Lb. per line of 20 plants.	*Percentage yield.*
381 (2) 7 × 8	10.78 ± 0.210	100.0
381 (2) 24 × 68	6.88 ± 0.386	63.8
381 (2) 1 × 58	3.91 ± 0.392	36.6

Possibly this may be an extreme case, but differences in vigour of the order of 80 to 150 per cent. are not uncommon.

The figures given below also illustrate the extreme variability in vigour of growth which frequently occurs in in-bred populations of the same parental origin. In this case seedlings of four F_2 progenies derived from 230 (1) family were planted twenty inches apart in adjoining plots. The weights of the first cut in the second year are expressed in lb. of green fodder per 100 plants actually weighed.

	No. of plants.	*Lb. per 100 plants weighed.*	*Percentage yields.*
230 (2) 59 × 92	80	93.0	100.0
230 (2) 15 × 75	98	54.1	58.2
230 (2) 27 × 28	140	48.7	52.4
230 (2) 18 × 41	120	39.8	42.8

The yields in the second year of five other second generation populations of common origin were as follows :—

	No. of plants.	Lb. per 100 plants weighed.	Percentage yields
344 (2) 263 × 261	80	86.4	100.0
344 (2) 265 × 266	100	80.1	95.4
344 (2) 261 × 265	172	72.5	83.9
344 (2) 263 × 266	210	61.6	74.8
344 (2) 261 × 262	55	35.0	41.2

These variations in the vigour of growth and productiveness of in-bred populations of the same generation and of common origin are undoubtedly due to segregation of factors affecting growth.

Summary.

The results of the earlier investigations extending for the most part over the period 1925 to 1930 relating to the effect of in-breeding on the fertility, germination, longevity, and vigour of growth of red clover are reported in this paper. The conclusions drawn from these results are briefly summarized as follows :—

(1). Fertility of cross-compatible plants does not appear to be depressed by in-breeding. The average number of seeds produced in fifty F_1 sib-matings was 58.76 per cent. and the average fertility of the same plants when out-crossed was 58.26 per cent. The mean fertility of $F_2 \times F_2$ matings was 61.73 per cent. and of the corresponding out-crosses 64.45 per cent.

(2). In-bred seeds were found to be quite as viable as out-bred seeds. The mean germination of F_2 seeds was 80.8 per cent. and of the corresponding F_1 seeds 80.7 per cent. While the percentage germination of the F_3 and out-bred seeds was 78.2 and 77.3 per cent. respectively.

(3). The energy of germination of the seeds is not affected by in-breeding.

(4). During the early stages of growth the out-bred seedlings were much more vigorous than the in-bred seedlings. After about eight weeks' growth the cross-breds were 18.6 per cent. taller than F_2 seedlings, and 33.4 per cent. taller than F_3 seedlings.

(5). The second and third generation in-bred populations show a decided and progressive reduction in longevity. Highly persistent F_1 plants segregated in the second and third generations into progenies with high and low persistence.

(6). In-bred progenies showed a very marked and progressive decrease in productivity from the first to the third generation. On the average the yields of F_2 populations were about 60-65 per cent. and of F_3 populations about 40-50 per cent. as compared with the F_1 progeny.

(7). The productivity of the individual plants within the in-bred progenies displayed great variability, but the most vigorous in-bred plants were less productive than the heaviest yielding individuals in the corresponding cross-bred populations.

(8). In-bred progenies of the same generation and ancestry often exhibited wide variation in regard to vigour of growth and productiveness. This is probably due to the segregation of factors affecting growth.

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THE SHAPE OF THE SHOOT-BUD PROPHYLL IN THE RYE-GRASSES AND BROAD-LEAVED FESCUES AS A DIAGNOSTIC CHARACTER FOR THEIR SEPARATION IN THE FIELD.

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i. Introduction.

The accurate identification of many of our pasture plants in their vegetative state often presents difficulties, especially under the conditions found in a closely grazed sward. This applies with especial force where the rye-grasses (*Lolium perenne* and *L. italicum*) are grown in association with meadow fescue (*Festuca pratensis*) and perhaps tall fescue (*F. arundinacea*), as is frequently the case in critical seeds mixture trials.

The general morphological similarity of these species under sward conditions makes it essential that the investigator should have at his disposal one or more characters upon which to base his identification. In practice constant handling of the plants helps a great deal and, in fact, many of the characters upon which the experienced agronomist depends are the fruits of this close familiarity. Thus, in certain cases, his identification may be based on some new contrasting character, while in others it may depend on empirical distinctions, relating possibly to a group of characteristics—none of which is ordinarily described in text-books.

Among a variety of such characters used by the agronomic staff of the Welsh Plant Breeding Station is one relating to differences in the shape of the buds in the grass shoot, especially those of Italian rye-grass and meadow fescue which, under conditions of close grazing, present extraordinary difficulties in

identification. The use of shoot-buds as a criterion for the separation of these species during the course of pasture analysis was brought to the notice of the writer by Mr. William Davies, Grassland Investigator at the Station.

The results of an inquiry to determine more fully the nature of the characteristics possessed by these shoot-buds are presented below.

ii. Material and Methods.

The material used in this investigation was derived from seedlings grown in boxes for the purpose, as well as from tillers of plants taken from the field. The sheath was removed from each shoot, and its basal portion, with the attached bud, placed in 70 per cent. alcohol and left until required. It was necessary for satisfactory observation to remove the buds from the parent shoot. The buds were then placed on a slide, adaxial side downwards, and mounted in concentrated glycerine. The bud outlines were drawn by means of a *camera lucida*.

iii. Assessment of the Results.

(1) *Shape of prophyll.*

The first leaf or prophyll of the bud acts as a sheath and its shape or outline provides the chief diagnostic character of the bud (see Text-fig. 1). A summary of the distinctive features of the bud form of each species is set out below.

Italian rye-grass. (Text-fig. 1 (A)). Outline tapering, the slope inwards starting from a position relatively well removed from the apex, which is always more or less acute.

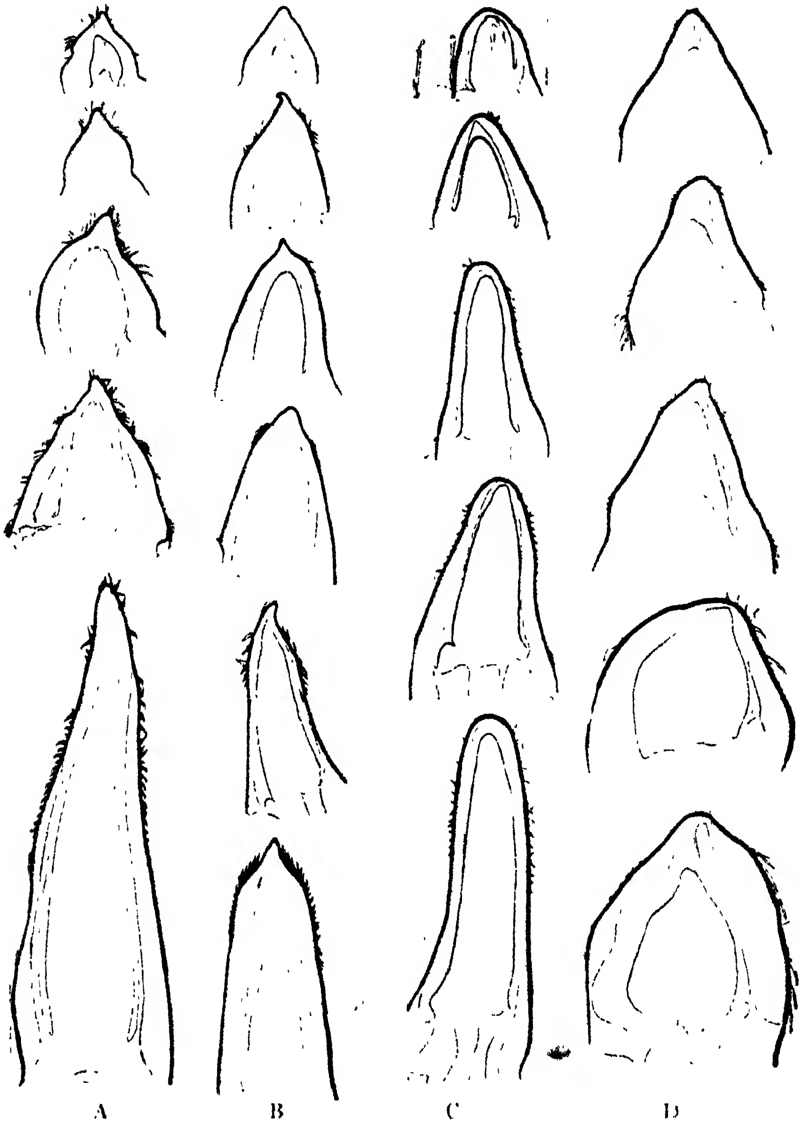
Perennial rye-grass. (Text-fig. 1 (B)). The sides of the buds converge only slightly at first, but do so rather abruptly in their upper half or third to form a comparatively well defined shoulder and a fairly acute apex.

That the buds of these two species are sometimes indistinguishable may be due to the fact that inter-breeding occurs so readily between them. It may also be due to reciprocal contamination by each other's seed.

Meadow fescue. (Text-fig. 1 (C)). The apex is blunt or rounded, and even when the prophyll is decidedly cone-shaped the apex is still more blunt than acute. This rounded character of the apex will readily distinguish meadow fescue from either of the rye-grasses.

Tall fescue. (Text-fig. 1 (D)). The buds show a greater variation of form than in any other species. In general, however, the shape of the apex is nearest that of meadow fescue since

the majority of the buds are somewhat blunt. Some of the buds nevertheless tend to resemble the rye-grasses, but their relatively great width and large size would as a rule serve to distinguish them.



TEXT-FIG. 1.

Outlines of shoot-bud prophylls in A. *Lolium italicum*, B. *L. perenne*, C. *Festuca pratensis*, D. *F. arundinacea*. The prophyll apex is acute in the rye-grasses, but rounded in meadow fescue (C). Hairs on the apex of the bud are usual in Italian (A) but rare in perennial rye-grass (B). The shape of the prophyll and the position of the hairs in tall fescue (D) show considerable variation, but the presence of hairs at the base is characteristic. x 15.

Tall fescue possesses a convenient and effective diagnostic character in the hairs on the auricle ledges of the leaf blades. This feature, to which my colleague Dr. T. J. Jenkin a number of years ago drew attention, separates this species not only from the rye-grasses, but also from meadow fescue. In the unlikely event of all the auricles having been destroyed, or eaten by pests, the buds would then provide a means of identification in doubtful cases.

(2) *Hairs of prophyll.*

The presence or absence of hairs on the prophyll supplies a secondary or confirmative character to that of bud shape. The position of the hairs and their general characteristics are shown in Text-fig. 1. In some of the drawings the hairs are shown in solid black, a procedure which was subsequently discarded because it tended to exaggerate their importance and to suggest that they were readily observed, which in the field is not always the case. The hairs are always unicellular. A review of the situation with regard to the hairs is given below.

Italian rye-grass. Hairs present on every bud examined. They are usually distributed along one or both sides of the prophyll, spreading right up to and very frequently on to the apex itself. The hairs are possibly more readily seen in this species than the others. The formation of hairs at the base of the prophyll, opposite the bud node, was not common, and those developed were very small as a rule.

The first (true) leaf within the prophyll also develops hairs, which are often very prominent at the apex. They may often be seen under the microscope, even when still enclosed within the prophyll.

Perennial rye-grass. The hairs, which may be absent especially from the smaller buds, are chiefly to be found on the shoulders where they can be fairly dense. They appear only rarely on the apex or far down along the sides. Basal hairs are uncommon. The development of hairs on the first leaf is not general, but is by no means infrequent; they are often well developed on the apex.

Meadow fescue. The apex of the prophyll is normally devoid of hairs, but they are usually to be found on one or both shoulders, though they are rarely dense. They may extend down and even reach to the base of the bud. Buds of fair size ($1\frac{1}{2}$ to $2\frac{1}{2}$ mm. long) may be quite free from hairs. Basal hairs are not uncommon, but they are not strongly developed.

The first leaf of the bud develops hairs much less frequently than perennial rye-grass—but they do appear, and on its apex.

Tall fescue. This species shows as considerable a variability in respect of hair as it did for shape. The prophyll may be glabrous or may show from few to many hairs, arranged along its sides, shoulders and/or apex. Basal hairs are usually present, on either one or both sides of the prophyll. They show greater development in tall fescue than in any of the other species. The first leaf may have hairs on its apex.

(3) *Comparison of coleoptile with prophyll.*

The coleoptile of the seedling, and the prophyll of the shoot-bud form protective sheaths for their respective first leaf. Although the conditions under which they each function are so different, it was thought that the coleoptiles might still show morphological differences comparable with those in the shoot-buds. To this end coleoptiles from each of the four species under consideration were examined.

The outlines of the coleoptiles are not comparable with those of the prophyll, and do not possess any outstanding diagnostic features in the four species.

(4) *Concluding Note.*

The criterion of relative shape used for the separation of meadow fescue from the rye-grasses was based on distinctive differences. These differences can readily be demonstrated in the field with a pocket lens magnifying 10 to 15 diameters. It is possible, with experience, to recognise the form of the bud apex in certain cases without the aid of a lens.

The detection of the hairs, however, requires the use of the lens, and even then their determination may not be easy. The observation of the hairs is often a function of the incidence of the light on the bud. In this connection it has been found helpful to view the bud not from the front, but from above its apex. The basal hairs on the prophyll will probably not be readily observed in the field, even in tall fescue.

iv. Summary.

(1) It has been shown that the form of the prophyll of the buds within the sheath at the base of a shoot has a definite diagnostic value for certain grasses.

(2) The character of the buds can be readily determined in the field by the aid of a pocket lens. It is unfortunately necessary to pull up one or more shoots from the ground and then remove the enveloping sheath before determination can be made.

(3) In meadow fescue (*Festuca pratensis*) the apex of the prophyll is blunt and rounded, and generally free from hairs.

(4) In the rye-grasses the bud has an acute or pointed apex. Italian rye-grass (*Lolium italicum*) usually has hairs right on the apex of the bud, and this fact, together with its more tapering sides, may serve to separate it from perennial rye-grass (*L. perenne*) in cases of doubt.

(5) The buds of tall fescue (*Festuca arundinacea*) show considerable variation in the form of the outline, but the plump, broad buds, with their more or less blunt apex, should serve to distinguish them. The position of the hairs is also variable.

In this species, however, the presence of asperities (or hairs) on the auricles of the leaf blade provides an almost infallible criterion for its recognition.

(6) The seedling coleoptile shows little or no correlation with the prophyll of buds from a more mature plant of the same species, either as regards the shape of their respective outlines or in respect of the presence of epidermal hairs.

SEED PRODUCTION OF A PASTURE TYPE OF RYE-GRASS.

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Leafy and persistent pasture types of perennial rye-grass have a definite place in British agriculture, but they tend to be less prolific in seed production than the earlier and more stemmy hay types, so that it is necessary to investigate methods of seed production in such types in order to develop a technique by which the price of seed may be brought as low as possible.

A preliminary experiment, on a farm scale, was laid down at Hockleton, Chirbury, in 1932, in order to compare three methods of growing "Aberystwyth S.23" pasture perennial rye-grass for seed.

Experiment 1.

The land was a light loam which had grown an oat crop in the previous year. The district of Chirbury has an average annual rainfall of about thirty inches.

The three methods of growing this strain for seed were :—

(*a*) Two acres sown broadcast at the rate of 28 lb. per acre, under spring barley.

(*b*) Two acres sown in drills 2 ft. apart at the rate of 6 lb. per acre under spring barley.

(*c*) One acre sown in drills 2 ft. apart at the rate of 6 lb. per acre without a nurse crop.

Satisfactory establishment of rye-grass was effected on each of the areas, and the drills sown under the cover crop were cultivated thoroughly after the barley was harvested, the acre sown without the cover crop having been horse-hoed periodically from the beginning.

In the spring of the first harvest year a scheme of differential manuring was applied to each of the three areas; plots of 1/50th acre net were marked out and four treatments were compared.

(*a*) Superphosphate 4 cwt. per acre; sulphate of potash 2 cwt.; nitro-chalk 2 cwt.

(*b*) Superphosphate 4 cwt. per acre; sulphate of potash 2 cwt.

(*c*) Superphosphate 4 cwt. per acre.

(*d*) Control.

Each treatment was replicated four times in randomized blocks, in each of the three areas. No grazing by farm stock was permitted before harvest, but a number of hares managed to obtain a certain amount of illicit grazing during the winter and early spring.

Results.

Five quadrat samples were taken from each plot immediately before harvesting the crop, in order to make counts of barren and fertile tillers.

Of all the plots only two exhibited a tendency to lodge at harvest time; they were PKN plots in the area sown without a cover crop.

The broadcast plots ripened quite five days before the earliest of the plots in drills, and the plots sown in drills under barley matured from two to three days earlier than the drills sown without a cover crop.

Although the experiment was laid down on apparently uniform land, the data in relation to methods of sowing can be regarded only as pointers, the three differentially sown areas not having been replicated.

In Table I the data relative to barren and fertile tillers from plots variously treated have been brought together.

It will be observed in Table I that almost without exception the numbers of barren and fertile tillers have been influenced significantly by the addition of nitrogen to the mineral manures,

while the reverse is generally true of the influence of the phosphates or phosphates with potash.

TABLE I.

Showing per unit of area (a) the number of fertile tillers and (b) the number of barren tillers of Aberystwyth S.23 pasture perennial ryegrass produced under various methods of sowing and manuring.

Method of Sowing.	*Tillers per Unit of Area*	*Manurial Treatments in Cwt per Acre*				*Mean.*	*S E.*
		PKN.	*PK.*	*P.*	*Control.*		
		Super .. 4 S. Potash 2 N. - chalk 2	Super. .. 4 S Potash . 2	Super ... 4	Nil.		
A. Drills 2 feet apart (without nurse crop).	Fertile ... .. Per cent of mean Barren . .. . .. Per cent of mean	2225 119.2 84 36.0	1747 93.6 264 113.3	1734 92.9 275 118.0	1759 94.3 309 132.2	1866 100.0 233 100	97.5 5.2 23.4 10.0
	Total . ..	2309	2011	2009	2068		
B. Drills 2 feet apart sown under barley	Fertile .. . . Per cent. of mean . Barren . .. . . Per cent of mean	1056 117.5 293 189.0	865 96.2 105 67.7	846 94.1 115 74.2	830 92.3 106 68.4	899 100.0 155 100.0	61.6 6.9 18.2 11.7
	Total	1349	970	961	936	—	—
C. Broadcast under barley	Fertile . . . . Per cent of mean Barren . . . . Per cent. of mean	1617 137.8 357 215	993 84.6 73 43.9	1164 99.2 94 56.6	912 77.7 141 84.9	1173 100.0 166 100.0	167.2 14.3 65.9 39.7
	Total	1974	1066	1268	1053	—	—
Average number of fertile tillers . . .		1633	1202	1248	1167	—	—
Average number of barren tillers		244	147	161	185	—	—
Average Totals		1877	1349	1409	1352	—	—

The very marked and differential effect of nitrogen on the numbers of barren tillers under the different methods of growing the seed crop is of practical importance. Nitrogen in conjunction with phosphate and potash has been efficacious, not only in converting all the barren tillers in the plots grown without a cover

crop into fertile ones, but also actually in producing a greater number of stem shoots than the total number of shoots in each of the other treatments. Similar results attend the application

TABLE II.

Showing the yield of seed in lb. per acre of Aberystwyth S. 23 pasture perennial ryegrass grown by various methods of sowing and manuring.

Method of Growing.	*Seed Yield.*	*Manurial Treatments in Cwt. per Acre.*				*Mean.*	*S.E.*
		PKN.	*PK.*	*P.*	*Control.*		
		Super...... 4 S. potash .. 2 N.-chalk 2	Super...... 4 S potash .. 2	Super...... 4	Nil.		
A. Drills 2 feet apart without nurse crop.	Lb. per Acre .... Per cent. of mean ...	563.5 119.9	431.6 91.8	434.3 92.4	450.7 95.9	470.0 100.0	27.73 5.9
B. Drills 2 feet apart sown under barley	Lb. per Acre .... Per cent. of mean ...	326.2 131.6	218.0 88.0	231.7 93 5	214.8 86.7	247.7 100.0	13.54 5.5
C. Broadcast under barley.	Lb. per Acre .... Per cent of mean ..	292.4 151.2	153.0 80 3	155.2 81.5	161.0 84.5	190.4 100.0	15.77 8.3
	Average yield for manurial treatments	394.0	267.5	273.7	275.5	—	—

of manures on the drills sown under barley, except that here the number of barren tillers in the **PKN** plots is substantially greater than in the plots subjected to the other three treatments. Undoubtedly the reason for this is that the plants grown without

a cover crop were in a more robust condition, and able to make use of the complete fertilizer not only to increase the number of tillers, but to accelerate their development into stem shoots as well.

The comparatively greater number of barren shoots produced in the PKN plots of the broadcast areas than in the PKN plots sown without a cover crop also shows the retarding effect of barley on plant development.

Seed Yield.

A comparison of the yield of seed on the basis of 100 per cent. purity can be made from Table II.

One thing stands out fairly clearly in Table II, and that is the superiority in rye-grass seed yield in the plots given the most favourable conditions of establishment and manuring. Mineral manures have here again failed by themselves to influence the yield of seed, as they failed to influence tiller counts.

The increase of seed due to PKN is both relatively and actually greater in the broadcast area that in the plots in drills. Very probably the inter-drill cultivations account, at least partly, for the relatively higher level of seed yield in the control plots of the areas sown in wide drills.

The data from this experiment show that although the number of fertile tillers is constantly higher in the broadcast plots than in the drill plots, also sown under barley, the seed yields are invariably higher in the latter. It would appear that when radically different methods of seed growing are compared there is no correlation between the number of inflorescences and seed yield. Table III gives one explanation for this result.

TABLE III.

Showing the weight per 1,000 seeds in gm. of Aberystwyth S.23 perennial rye-grass grown for seed (a) under various methods of sowing and (b) under various manurial treatments.

Method of Growing.		*Manurial Treatments.*			
		PKN.	*PK.*	*P.*	*Control.*
A. Drills 24 inches apart sown without a nurse crop.	Average weight per 1000 seed in gm.	1.146	1.196	1.196	1.168
B. Drills 24 inches apart sown under barley	do.	1.171	1.219	1.172	1.166
C. Broadcast under barley	do.	1.015	1.036	1.036	1.047

From Table III it will be seen that the size of seeds as measured by weight of 1,000 seeds from the broadcast plots tends to be smaller under each treatment than the seed from the corresponding plots of the area sown in drills under barley. It is also

possible that the stimulus of inter-drill cultivation has produced more robust inflorescences, a greater number of spikelets per inflorescence, and a greater number of florets per spikelet in the 2 ft. drills than in the broadcast plots.

The tendency for the PKN plots to produce rather lighter seeds than the others may be due to a larger number of weak inflorescences produced late in spring by the stimulus of the complete fertilizer.

Experiment 2.

A further experiment was laid down at the Station's farm to test the relative merits of six sowing methods of seed production, again of Aberystwyth S. 23 ryegrass. The six methods of sowing were as follows :—

(*a*) Drills 24 inches apart, sown at the rate of 5 lb. per acre.
(*b*) Broadcast at the rate of 30 lb. per acre.
(*c*) Drills 6 inches apart at the rate of 30 lb. per acre.
(*d*) Drills 24 inches apart with pasture timothy seed mixed with the rye-grass seed in the ratio of 1 : 6 and sown together at the rate of 5 lb. per acre.
(*e*) Broadcast mixture of rye-grass and timothy in the ratio of 2 : 1 at the rate of 45 lb. per acre.
(*f*) Alternate 6-inch drills of rye-grass and timothy sown at the rate of 2.5 and 2.0 lb. per acre respectively.

This experiment was laid down in the form of a Latin Square, each plot having a net area of 1/50th acre after allowing for the borders to be cut at harvest time.

No cover crop was sown on the land, a light loam, which grew a corn crop in the previous year, after having been in inferior pasture for many years. The manurial treatment prior to sowing the seed consisted of superphosphate at 3 cwt. per acre and potash salts at 2 cwt. per acre.

Timothy was included in the seeding of some of the plots in order to see whether it would to any extent prevent the rye-grass from lodging. The pasture type S. 49 was thought less likely to interfere with the pollination of the rye-grass than other types.

Establishment proved ultimately to be satisfactory, although in the early stages and during a period of drought growth was far superior in the drilled plots in comparison with the broadcast plots, presumably on account of the greater proximity of the drilled seed to soil moisture than of that sown on the surface.

The plots were not grazed from seeding to harvest, and in early April of the first harvest year manures were applied at the following rates per acre : superphosphate 4 cwt., kainit 4 cwt., and nitro-chalk 2 cwt.

In the autumn of the first harvest year nitro-chalk was applied at the rate of 1 cwt. per acre in preparation for the second crop, and a further dressing of superphosphate 3 cwt., kainit 3 cwt., and nitro-chalk 2 cwt. was applied in the spring of the second harvest year.

Results.

Both broadcast and six-inch drill plots matured quite four days earlier than the wide drill plots. The plots of timothy alternating with rye-grass in narrow drills and those containing timothy mixed with rye-grass stood approximately 30 per cent. better than those without timothy, although there was a tendency for all the plots to lodge.

Yields of rye-grass seed from the first and second harvest years are given in Table IV.

TABLE IV.

Showing the yield of seed per acre in the first and second harvest years of Aberystwyth S. 23 pasture rye-grass grown (a) in drills 24 inches apart; (b) in drills 24 inches apart with timothy seed mixed in the ratio of 1 : 6 of rye-grass; (c) broadcast; (d) broadcast with timothy mixed in the ratio of 1 : 2 of rye-grass; (e) drills 6 inches apart and (f) drills six inches apart of rye-grass and timothy alternating.

Yield of Seed.	*Method of Seeding.*							
	24 inch drills.	*Broadcast.*	*6 inch drills*	*24 inch drills with Timothy Seed Mixed*	*Broadcast with Timothy.*	*Alternating 6 inch drills of Ryegrass and Timothy*	*Mean*	*S.E.*
1st Harvest Lb. per acre .	711.8	647.5	657.3	682.5	535.2	547.0	627.0	± 34.5
Percentage of mean	113.5	103.2	104.8	108.8	85.7	87.4	100.0	± 5.5
2nd Harvest. Lb. per acre .	161.0	122.5	129.4	156.8	100.0	109.3	129.8	± 10.88
Percentage of mean	124.0	94.1	99.7	120.8	77.0	84.2	100.0	± 8.4

The evidence suggests that a strain of pasture rye-grass sown pure by broadcasting, or in drills 6 inches apart, is, in the first harvest year, capable of producing seed yields not significantly less than those produced from drills sown 2 ft. apart. The pasture timothy added to the rye-grass seeding does not seem able to help in the matter of rye-grass seed yield, although it helped very materially to prevent the rye-grass from lodging. It is probable, however, that the rye-grass *cum* timothy plots could have been

cut more easily with a binder than the pure plots of rye-grass, and that there would have been less wastage of seed.

In the second harvest year the rows 2 ft. apart produce higher seed yields than broadcast or six-inch-drill plots, but even so very poor yields are shown in all cases after generous applications of fertilizers on this land, which had been down so long under inferior pasture; a disturbing feature in the second harvest year was the rapid encroachment of volunteer grasses. Yorkshire fog, sweet vernal and bent appeared in greatest abundance on the plots where inter-drill cultivation was not applied.

Experiment 3.

Having now obtained evidence that a pasture rye-grass grown broadcast does not produce significantly lower seed yields in the first harvest year than crops grown in drills two feet apart, we may consider whether the adverse effect of a cover crop shown in Experiment 1 can be overcome.

The following plots were laid down on the Station's farm in order to elucidate this problem. Duplicate plots of 1/14th acre each were established on land very similar to that used in Experiment 1.

Plot (*a*) 24-inch drills of Aberystwyth S. 23 rye-grass.
(*b*) 24-inch drills of Aberystwyth S. 23 rye-grass sown under barley (120 lb. per acre).
(*c*) 6-inch drills.
(*d*) 6-inch drills sown under barley (120 lb. per acre).
(*e*) Broadcast.
(*f*) Broadcast sown under barley (120 lb. per acre).

Excellent establishments were obtained on all the plots, and those sown under barley received nitro-chalk at the rate of 1½ cwt. per acre after the cover crop was harvested. All the plots received an application of nitro-chalk in the following spring at the rate of 1½ cwt. per acre.

The " nurse crop " plots retained a fresher green colour throughout the winter months than the no-nurse crop plots, although they naturally were not so forward in growth as the latter.

For the second harvest year seed crops an autumn application of nitro-chalk (1½ cwt. per acre) and a spring application of superphosphate (3 cwt. per acre), potash salts (3 cwt.), and nitro-chalk (1½ cwt.) was given.

Pasture strains of rye-grass compared with hay strains are so slow in developing in the initial stages of the life of the sward

that the seedlings in this experiment interfered very little with the harvesting and conditioning of the cover crop, although the grass and corn were sown on the same day.

Results.

The broadcast plots showed a tendency to lodge rather more severely than plots in wide drills, but they were inclined to lodge more in the same direction than the latter and so they were quite capable of being cut one way by machinery. The broadcast plots in this experiment also matured a few days earlier than the wide drill plots.

Data bearing on the seed yields in Experiment 8 are submitted in Table V.

TABLE V.

Showing yield of seed in lb. per acre of Aberystwyth S. 23 pasture rye-grass grown (a) in 24-inch drills; (b) in 24-inch drills under barley; (c) in 6-inch drills; (d) in 6-inch drills under barley; (e) broadcast and (f) broadcast under barley.

Average Seed Yields.	*24 Inch Drills.*		*6 Inch Drills.*		*Broadcast.*	
	Sown under Barley	*Sown without Barley*	*Sown under Barley*	*Sown without Barley*	*Sown under Barley*	*Sown without Barley*
1ST HARVEST YEAR. Lb. per acre	417	404	438	385	411	457
Relative	103	100	108	95	102	113
2ND HARVEST YEAR. Lb. per acre	218	204	118	125	118	121
Relative	107	100	58	61	58	60

Although the data given in Table V are derived from duplicate plots only, the indications are that the depressing influence of a barley cover crop on the succeeding seed crop of pasture rye-grass, as seen in Experiment 1, can be removed by stimulating the young rye-grass seedlings with a nitrogenous fertilizer as soon as the cover crop is removed. The average seed yield from all the plots sown under barley is at least as great as the average yield from the no-nurse crop plots; although the plots sown under barley were slightly later in ripening, they stood up better than the others at harvest time.

Again it will be noted that the yields of seed from the broadcast plots, and the narrow drill plots are not greatly different from those on the wide drill plots in the first harvest year. The higher yields of the wide drill plots in the second harvest year tally with those in Experiment 2, but though they surpass the broadcast yields they can hardly be regarded as satisfactory commercial yields.

Experiment 4.

It is as difficult to attain precision in respect of ideal seed rates as it is in respect of any other technical aspect of seed production. An experiment was laid down on Station land to study the effect of rates of seeding on the seed yield of Aberystwyth S.23 rye-grass, and also the influence of a proportion of white clover and timothy seed mixed with the rye-grass seed on the resulting seed crop of the rye-grass.

The soil in this case also was a medium loam, which had been fallowed in the previous year and had a light application of superphosphate and kainit.

The following seed rates in lb. per acre were compared :—

(*a*) Aberystwyth S.23 rye-grass 12 lb., Scotch timothy 4 lb., wild white clover 3 lb.

(*b*) Aberystwyth S.23 rye-grass 18 lb., Scotch timothy 4 lb., wild white clover 3 lb.

(*c*) Aberystwyth S.23 rye-grass 24 lb., Scotch timothy 4 lb., wild white clover 3 lb.

(*d*) Aberystwyth S.23 rye-grass 36 lb., Scotch timothy 4 lb., wild white clover 3 lb.

(*e*) Aberystwyth S.23 rye-grass 24 lb., Scotch timothy 4 lb.

(*f*) Aberystwyth S.23 rye-grass 24 lb., wild white clover 3 lb.

Each of the plots measured 1/200th acre, and each seeding was replicated six times in randomized blocks. The shape of the ground would not allow a Latin Square arrangement to be set up. A perfect seed bed was prepared and the seeds were broadcast under very favourable conditions, without a cover crop, during the first week in May. Ample rain fell later, so that establishment was assured.

Results.

No counts were made of established plants, but during the first few months of growth it was observed that the plots receiving the lighter seed rates were distinctly sparser than those receiving the heavier seed rates. This difference became less distinct as growth proceeded, and was not at all pronounced at harvest time.

Growth was very strong by autumn, and the area (approximately ¼ acre, including borders) provided 117 sheep days' grazing from the 12th to the 25th of March, by which time the sward had been grazed down fairly hard. All the plots received nitro-chalk at the rate of 2 cwt. per acre during the following week.

At harvest time it was found that the white clover, although not altogether suppressed through the system of management, was very little in evidence. It was observed, however, that the

plots sown without the clover had a tendency to ripen earlier, which indicates that in spite of the management calculated to

TABLE VI.

Showing (a) the effect of various rates of seeding on the seed yield of Aberystwyth S. 23 pasture rye-grass; (b) the effect of adding 4 lb. of ordinary Scotch timothy per acre and 3 lb. of wild white clover per acre to the rye-grass seeding on the seed yields of rye-grass.

	Rates of Seeding in Lb. per Acre						*Mean.*	*S.E.*
	Ryegrass . 12 Timothy . 4 Clover 3	Ryegrass . 18 Timothy . 4 Clover . 3	Ryegrass . 24 Timothy . 4 Clover . . 3	Ryegrass . 36 Timothy . 4 Clover .. 3	Ryegrass . 24 Timothy . 4	Ryegrass . 24 — Clover ... 3		
Seed yield lb. per acre . .	442	472	462	456	458	470	460	27.74
Seed per cent	96.1	102.6	100.4	99.1	99.4	102.1	100.0	6.03
Weight per 1000 seed in gm	1.569	1.584	1.510	1.557	1.564	1.544	1.554	—
Weight per 1000 relative to mean	100.9	101.9	97.1	100.1	100.6	99.3	100.0	—

keep the clover in check the latter still exerted some influence on the rye-grass.

The most obvious result from the differential seeding was the manner in which timothy assisted in propping up the rye-grass. In general the rye-grass *cum* timothy plots stood 50 per cent. better than those without timothy. This assistance provided by Scotch timothy not only facilitates the cutting of the crop by means of machinery, but also the binding of the crop into tidy sheaves, for the longer stemmed timothy helps to keep the rye-grass crop straight as it is drawn up by the binder canvas. As the timothy heads are generally a good deal longer than the rye-grass in the stook, they form a protective cap over the latter when the top of the stook is tied.

Data are adduced in Table VI to show the effect of differential seeding on seed yield.

In Table VI the differences between the average yields of seed from the variously treated plots are remarkably small. Both the Z test and the Standard Error show that no significance whatever can be attached to these differences. This means that under optimum conditions of sowing the effective seed rate of pasture rye-grass can be as low as twelve pounds per acre. In ordinary circumstances, however, and particularly when seeding under a nurse crop, twelve pounds per acre is probably too light a seeding to meet the various contingencies which might arise. As in the seed yields the differences between the weights per 1,000 seeds under various treatments are negligible.

Experiment 5.

A question frequently asked by seed growers in the border counties of England and Wales is whether spring grazing of a pasture rye-grass is detrimental to the seed crop to be harvested in the same year. Ordinary hay strains of rye-grass are generally grazed in spring, before being put up for seed, and Experiment 5 was laid down to obtain a measure of the effect of grazing on the seed crop of Aberystwyth S.23 rye-grass.

The area available for the experiment had been sown in autumn in drills two ft. apart, and had been mown for hay in the first harvest year. In the spring of the second harvest year the area was subjected to the following treatments :—

(*a*) Grazed and fertilized with PKN (1/100th acre plots replicated × 6).

(*b*) Fertilized with PKN (1/100th acre plots replicated × 6).

(*c*) Fertilized with PK (1/100th acre plots replicated × 6).

There were from three to four inches of growth on March 2nd, when sheep were hurdled on the (*a*) plots. The grazing was

sufficiently severe to remove as much as possible of the foliage without injuring the meristems of the leaf shoots. The grazing calculated per acre amounted to 208 sheep days and was completed within two days.

All the plots were fertilized with superphosphate 3 cwt. per acre, and kainit 4 cwt. per acre, during the first week of April. Plots (*a*) and (*b*) received in addition an application of nitro-chalk at the rate of 2 cwt. per acre.

Results.

Table VII provides data indicating the effect of spring grazing and manuring on the yield of seed from pasture rye-grass.

TABLE VII.

Showing the effect of grazing and manuring with P. (superphosphate 3 cwt. per acre); K. (kainit 4 cwt. per acre) and N. (nitro-chalk 2 cwt. per acre) on the yield of seed in lb. per acre of Aberystwyth S.23 perennial rye-grass.

Seed Yield.	*Treatment.*			*Mean.*	*S.E.*
	PK	*PKN*	*PKN + grazing.*		
Lb. per acre	546	626	672	614	28.55
Seed per cent. of mean	89.4	101.6	109.3	100	4.65

The data obtained from this experiment were subjected to the Z test, and treatment proved to be significant. By using the Standard Error in Table VII as a measure of probability it can be realized that a light grazing of pasture rye-grass in early March has no detrimental effect on seed yield. The grazed plots have on the average a significantly higher seed yield than the plots manured with phosphate and potash only.

The inference drawn from this experiment is that when a pasture type of rye-grass has been well established, and has made robust growth during early March, no harm follows judicious grazing if a top dressing, including nitrogen, follows.

Discussion.

It was observed that under the conditions obtaining for Experiment 1 a cover crop in the seeding year can effect a considerable reduction in the yield of seed of a pasture type of perennial rye-grass in the first harvest year. Even when a relatively generous dressing of a complete fertilizer was applied in spring the seed yield in the two-foot drills and broadcast plots

fell considerably below the yields from the plots sown in drills two feet apart without a cover crop. From this evidence the inference is drawn that where the soil is relatively light, and is not in a high state of fertility, spring manuring may not be efficacious in removing altogether the effect of a nurse crop on the seed yield, especially if the spring and early summer are inclined to be drier than in average years, as occurred in Experiment 1. In support of this contention it is noted that the response to the complete fertilizer is relatively greater in the plots sown under barley than in the plots sown without barley. Furthermore, the difference between the control plots and the plots receiving the complete fertilizer in the broadcast area is substantially greater than that obtaining between the control and the PKN plots of the area sown in drills under barley. This result can be explained by assuming that the barley crop has caused a decrease in soil fertility, and that the loss of fertility is less severe in the two-foot drills than in the broadcast area on account of the inter-drill cultivation applied to the former after the removal of the barley crop.

The relatively large numbers of leaf shoots produced in the PKN plots sown under a nurse crop, compared with the numbers in the PKN plots sown without a cover crop, indicate that the fertilizers were applied too late to induce full development in the plants.

Although it has been shown that under the conditions of the experiment from two to two and a half cwt. more seed per acre was obtained by sowing the seed without a cover crop, the cash value of the barley crop may more than compensate for the deficiency in the rye-grass seed crop. Relative prices of the cereal and the grass seeds at any given time have to be considered as well as relative yields under different methods of growing.

In Experiment 2 the seed crops of the same strain of rye-grass did not give a statistically greater yield of seed when grown in drills two feet apart than when sown broadcast. If this type of grass can yield approximately six cwt. of seed (100 per cent. pure) as it did in Experiment 2 on land of rather low natural fertility, then the broadcast method will appeal to seed growers even though the seed rate per acre is much higher than that required for drill sowing, and a slight increase in the amount of the fertilizers may be necessary. Wide drills make greater demands on labour, and growers eschew drills as far as possible for this reason.

Should the land be subject to weeds, or have a legacy of buried seed of inferior grasses in the soil, as occurred in Experiment 2, the broadcast method would definitely be proscribed.

There is a definite measure of safety in drilling the seed in narrow drills, as is normally done in several countries on the Continent, rather than broadcasting the seed, for the establishment of seedlings is more certain in periods of drought. Such narrow drills form virtually broadcast areas and are treated as such after sowing. Experiment 2 showed that the seed yield from the narrow drill plots approximated very closely to that of the broadcast plots.

The inclusion of a leafy pasture type of timothy, although it helped the rye-grass to stand up, had a distinct tendency to lower the seed yield of rye-grass when it was sown in comparatively large proportions. Had the crop, however, been harvested by means of a binder, instead of by hand, there would probably have been less wastage in harvesting on the plots where the timothy was included. Experiment 4 shows that better results attend a relatively light seeding per acre of ordinary Scotch timothy broadcast with rye-grass. This type of timothy is longer in the straw than the pasture timothy, and being earlier, besides having fewer leaf shoots than the latter, facilitates the binding of the crop more effectively. The relative paucity of barren shoots in this timothy allows a more rapid drying of the rye-grass in the stook than would be possible with a more leafy and later type of timothy. Pasture timothy is several weeks later in ripening than a pasture type of rye-grass, and thus the seed of both cannot be harvested together. The Scotch timothy seed thrashed out fairly well in the rye-grass crop, and the two types of seed can be easily separated, but this timothy, as a type, leaves much to be desired. The ideal type of timothy to use in this connection would be a good early hay type which matures its seed about the same time as the late rye-grass.

If the evidence brought forward from Experiment 3 is supported by further evidence from experiments carried out on different soils in different districts, in fact if the evidence proves generally true for most soil and climatic conditions in this country, then the cost of producing the seed of a leafy and persistent type of perennial rye-grass is considerably reduced by having sown it under a nurse crop of barley. The cost of nitrogenous fertilizer required to stimulate the rye-grass seedlings as soon as the corn is cut will be handsomely covered by the cash value of the barley crop, provided the subsequent rye-grass seed yield does not suffer

material reduction, and the evidence from Experiment 3 does not lead us to suppose that such a reduction would occur.

The data from Experiment 3 support the evidence from Experiment 2, where it was indicated that the seed yield in the first harvest year of a pasture rye-grass grown in drills two feet apart may not be significantly different from yields derived from crops grown broadcast. Second year seed crops have suffered marked reductions in both experiments, and both the broadcast or uncultivated plots tend to show lower yields than the wide drill plots. If further experiments can show that improved technique can result in satisfactory seed crops in the second harvest year, and such crops are not substantially less from areas broadcast under spring corn than from areas sown in wide drills under a similar cover crop, then there is much to commend in the method of sowing pasture strains of rye-grass grown for seed broadcast under spring corn. Broadcasts should not be considered unless the buried weed content of the soil is satisfactory, and if the seed is sown under a cover crop, particular attention must be given to proper manuring of the stubble after removing the corn.

From the evidence adduced in this paper the rate of seeding of a pasture type of rye-grass can under very favourable conditions be very low and yet produce a sufficiently satisfactory establishment for the purpose of seed production. If, therefore, a seed grower wishes to economise his seeding per acre he may do so by making the conditions for establishment as favourable as possible.

Early spring grass is usually a very valuable commodity on stock farms, and farmers are loth to do without it, so that if some of the ordinary young leys are to be replaced by swards of rye-grass, sown for seed, the grower would naturally require to be assured that at least some spring grazing is possible without serious hurt to the seed crop. The evidence presented in this paper shows that this can be done when the rye-grass has been well established in the previous year. It has been noted that this type of grass is relatively slow in developing in the initial stages, so that if spring grass is vital to the farm economy of the seed grower, he must exercise care to stimulate growth in the year of seeding, and if the seed is sown under corn, fertilizers should be applied as soon as possible after the removal of the corn.

Summary.

(1) Aberystwyth S.23 pasture rye-grass does not produce significantly more seed per acre in the first harvest year from rows two feet apart than from broadcast areas.

(2) Pure stands of rye-grass, and stands of rye-grass with a proportion of timothy mixed with it, suffer considerable reduction in the seed yields of the second harvest year on light land of rather low natural fertility. The yields from the second seed crop of the wide drills are significantly greater than from the broadcast areas; the crops are also cleaner in the drills.

(3) Phosphates, or phosphates with potash, when applied to pasture rye-grass in successive years fail to increase significantly the number of fertile tillers, and the seed yield, without the addition of nitrogen.

(4) The seed yield of pasture rye-grass sown under barley in drills two feet apart, or broadcast, compares very unfavourably with that obtained from drills sown without a cover crop, unless a nitrogenous fertilizer is applied in autumn as well as in spring on land not in a high state of fertility.

(5) Satisfactory establishment for seed production can be obtained from very low seed rates under favourable conditions.

(6) A few pounds of an early hay type of timothy can be of value in preventing lodging in rye-grass.

(7) Spring grazing is permissible on well established pasture rye-grass, provided a top dressing is given.

Acknowledgments.

Grateful thanks are due to Professor R. G. Stapledon, C.B.E., M.A., for his interest in this work; to Dr. T. J. Jenkin for helpful suggestions, and to Mr. Myrddin Williams, B.Sc., for assistance with statistical analyses.

THE CAHN HILL IMPROVEMENT SCHEME.

By Moses Griffith, M.Sc.,
Lands Director, Cahn Hill Improvement Scheme

This article is an attempt to give in broad outline a brief account of the origin, work and aims of the Cahn Hill Improvement Scheme. The origin of the Scheme can be traced back some twenty years, when Professor Stapledon made a survey of the uplands of North Cardiganshire and as a result became convinced of the vast potential scope for improvement in this and other mountain districts. Subsequently the Welsh Plant Breeding Station carried out small scale trials at various upland centres,

and as a result of such trials it was considered essential to acquire a fairly extensive tract of hill land over which complete control could be exercised. The generous response of Sir Julien Cahn to Professor Stapledon's appeal for the necessary funds made it possible to inaugurate the Cahn Hill Improvement Scheme and to provide for its maintenance over a period of seven years.

After exploring a number of possibilities it was finally decided to enter upon possession of a block of hill land on the Hafod Estate near Devil's Bridge, and fifteen miles from Aberystwyth.

These lands constitute the main area taken over by the Scheme, and it is here that the headquarters have been established. The area in question falls into three well defined units, namely :—

1. Pwllpeiran, one of the home farms, consisting of eighty-eight acres of fields, 195 acres of hill grazings, and seventy-eight acres of woodlands.

2. Prignant and Banc y Bont, consisting of fifteen acres of fields, 812 acres of hill grazing, and 17.5 acres of woodlands.

3. Nant Rhys, a sheep-walk of 2,200 acres.

In addition, and with a view to conducting trials over a wide range of conditions, two blocks of land with an aggregate area of 120 acres, were leased on the Whitton Hill near Knighton, Radnorshire. Seven acres of land at Ponterwyd, previously leased by the Welsh Plant Breeding Station for experimental purposes, were also taken over by the Scheme. Possession was taken of Pwllpeiran on Lady Day, 1938, and of the remaining lands at Michaelmas of that year(1).

The Pwllpeiran and Prignant hills range from about 1,000 to 1,350 feet above sea level. They carried a herbage of very inferior quality, comprising matt grass (*Nardus*) and sheep's fescue, with a small percentage of bent on the drier slopes, with flying bent grass (*Molinia*) on the wetter slopes, and *Molinia* and rushes on the flat portions. Nant Rhys is a very exposed and open sheep-walk, ranging in elevation from 1,500 to 1,850 feet. The greater part of the area is composed of *Molinia* and *Nardus* with deer grass (*Scirpus*); there are considerable areas of pure *Molinia*, and on a few of the drier slopes small areas of sheep's fescue with *Nardus* are interspersed.

The two maps on pages 214 and 216 show the farms of Pwllpeiran and Prignant respectively—the farms have been divided up into numbered fields and blocks of mountain land. The letters on the maps indicate areas to which reference is made in the text.

It should be mentioned here that in the selection of lands for the Scheme, the advisability of choosing land of too difficult a nature as regards poorness of soil, steepness of slopes and exposed situation as against the reverse was always borne in mind. Methods that have proved successful on the extremely difficult land of the Scheme are all the more certain to do so under less severe conditions. Similarly costs incurred by the Scheme should be in excess of those incurred for improvement of most of the hill land below the 1,200 feet contour.

Methods of Improvement.

A good deal of preliminary work, largely with improvised methods, had already been carried out by the Welsh Plant Breeding Station, and it seemed that a combination of some method of cultivation, manuring and seeding was essential if fairly rapid and economic results were to be obtained. The main methods of improvement are as follows :—

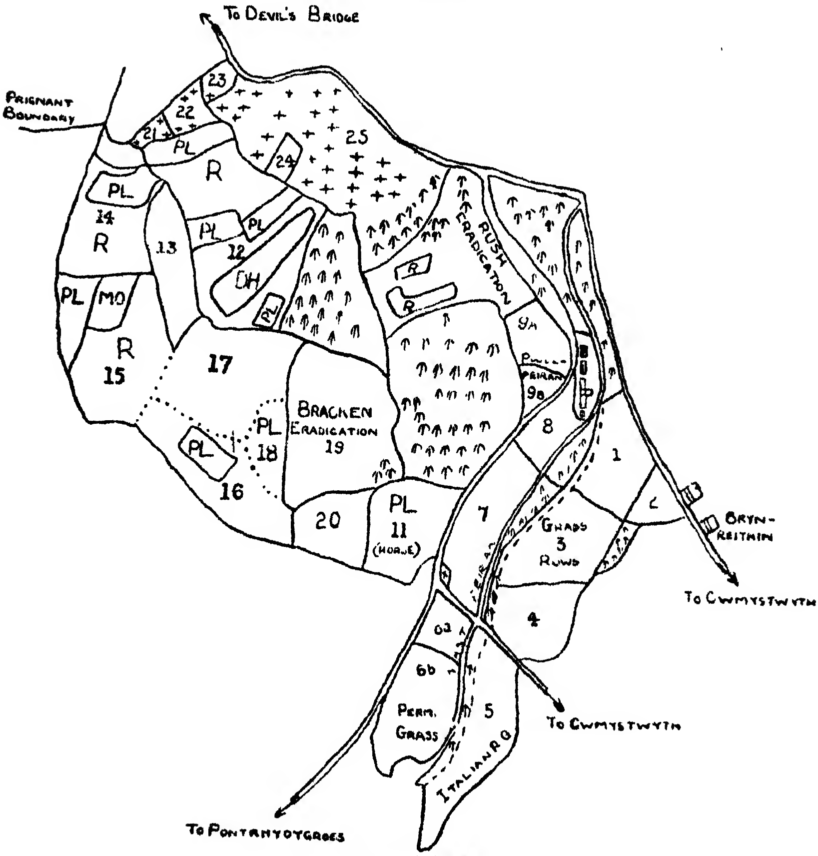
a. Ploughing. Over 150 acres of hill land have been ploughed as the first step in their improvement. A number of ploughs were tested but, as will be shown when dealing with implements, only the Ransome's Junotrac proved equal to the very arduous conditions. The ploughed surface is broken down by means of an Ogle Spiked Roller, to which is attached an Ogle Spiked Harrow. A great deal of previously unploughed upland contains a considerable amount of sterile subsoil with a fair amount of ferric oxide and the spiked roller and harrow do a much better job than the harrows alone, mixing up as they do the two layers of soil. The seed is sown broadcast or by horse drill, according to the severity of the slope, and manure is applied by a tractor-drawn fertilizer distributor, to the rear of which is attached a Howard steel flexible harrow, or an Ogle spiked chain harrow for covering the seed. All the hill areas have been ploughed by tractor, except Block 11, Pwllpeiran, which was horse ploughed to obtain comparative costing figures, and to demonstrate the possibilities of horse labour.

Representative areas treated on the above lines are indicated on the maps by the letters PL.

b. Rotary cultivation. Approximately 100 acres of hill land have been broken up with rotary cultivators, the great bulk with the Austral. This process can be carried out at any time of the year; if possible it is done in autumn or winter, and the up-torn clods are left until the weather permits of their being burnt (usually in May). Those areas, where a burn is not

possible, are fallowed for over twelve months, by which time the up-torn mat has largely rotted down, and after a good harrowing, a sowing tilth is obtained. The seeds are sown on the burnt

Cahn Hill Improvement Scheme.
Centre No. 1.
Pwllpeiran.



KEY TO MAP.

———	Field and Paddock Boundaries.	PL—Ploughed.
═══	Roads.	R—Rotary Cultivation
+ + + + + + +	Tree Stumps.	DH—Drastic Harrowing.
↑ ↑ ↑ ↑ ↑ ↑	Woodlands (mixed).	MO—Manured Only.
— — — — —	Footpaths.	MS—Manured and Seeded.
. . . .	Boundaries (old and unfenced).	

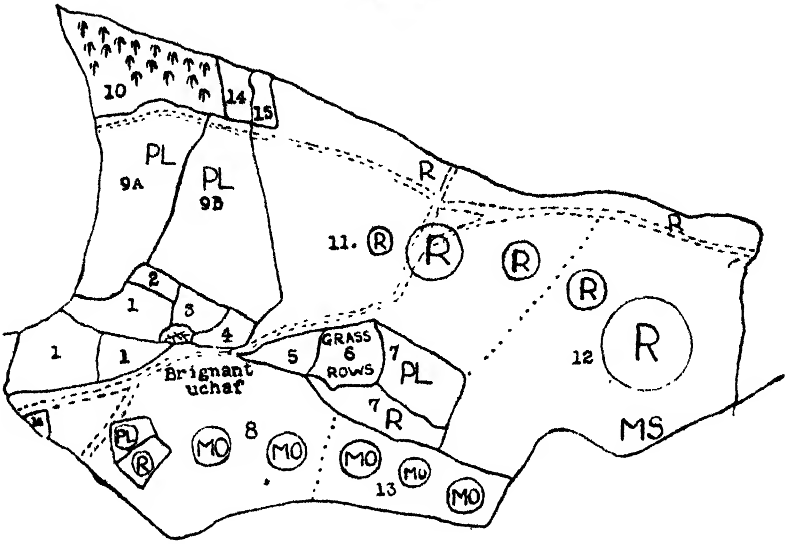
or harrowed surface without further cultivation and are manured and covered in a manner similar to that employed on the ploughed areas. Representative areas are indicated on the maps by the letter R.

c. Drastic harrowing. Only small areas have been dealt with according to this method, as on hill land with a fairly thick mat it has been found necessary to harrow at least four times before a tilth can be obtained. The most drastic harrows available, most of which have given excellent results under somewhat less severe conditions, have been employed, and are referred to briefly in the implement section. The cost of such harrowing is almost double that of rotary cultivation, and considerably in excess of ploughing costs. It is always advisable, where possible, to burn the mat prior to cultivation, and when a considerable amount of mat is torn out this should be collected and burnt. For this purpose a road sweeping brush has been found the most effective implement. Seeds are sown, manured and covered in the same manner as after ploughing. Representative areas treated by harrowing are indicated on the maps by the letters D.H.

d. Manured and seeded only, and manured only. A few uncultivated areas have been manured and seeded only, or manured only. On one steep area at Pwllpeiran, where timber had been felled, thus rendering cultivation very difficult, three plots of approximately two acres each were fenced off. These received various manurial treatments and wild white clover cleanings. As no cultivations were possible it was decided to graze them very hard; as many as 200 sheep being confined at various times in each two acres for twenty-four hours. This heavy treading, together with the hard grazing, was intended to give the new seeds a chance to establish themselves. After three years a definite improvement is visible in the herbage due to the increase of bent and fescue at the expense of *Nardus* and *Molinia*, but the take of clover, except on the wetter portions of the plots, is disappointing. (These plots are blocks 21, 22 and 23 on the Pwllpeiran map). On other areas manured and seeded only, where lack of fences has rendered intensive grazing impossible, the improvement has been very slow. (Representative area marked M.S. on Prignant map). On the other hand, certain areas of wet marshy land receiving only wild white clover cleanings and phosphates have responded extremely well to the treatment. (Representative area marked M on Pwllpeiran map). Areas consisting principally of bent and fescue dominant gulleys in a steep *Nardus* dominant hillside have responded well to dressings of phosphates, the sheep showing marked preference for such areas. (Representative areas marked M.O. on Prignant map).

Cahn Hill Improvement Scheme.

Prignant.



KEY TO MAP.

Field and Paddock Boundaries.	PL -Ploughed.
Woodlands (mixed).	R -Rotary Cultivation
Footpaths.	DH—Drastic Harrowing.
	MO -Manured Only.
. . . . . . Boundaries (old and unfenced).	MS—Manured and Seeded.

c. Relative value of the various methods of improvement. In reviewing these new pastures in their third or fourth grazing season, a number of facts stand out very clearly. It should be borne in mind that the majority of these improved blocks were sown without any nurse crop and were grazed by sheep within 4-7 weeks of sowing; in some cases they were not closed to stock at all. After ploughing there is a better take of the grasses than after rotary cultivation or harrowing, but clover makes much slower progress during the first two years, though afterwards it spreads rapidly. On the other hand the clover makes very quick progress after rotary cultivation and the take of grasses is quite good. After drastic harrowing the take of the grasses is generally poor; clover on the other hand, though slow to start with, appears to spread rapidly and forms a good turf with bent and fescue after the first two years. Ploughing seems to be much more satisfactory in eradicating the natural moss than are other methods of cultivation. In this connection the spread of moss is much less rapid after drastic harrowing than after rotary cultivation.

Manuring.

As a result of trials laid down on new and natural hill swards, the following general scheme of manuring has been evolved.

After the seed has been sown on ploughed or other cultivated areas, a manure distributor is fixed in front of the covering harrow and both are drawn together by the Caterpillar tractor. By this means a dressing of 6 cwt. per acre of 32-36 per cent. total phosphates slag, or an equivalent dressing of lower grade slags, is applied at time of sowing. The free lime contained in slag is very beneficial, if not essential, for obtaining a good take of seed. A small dressing of nitrogenous fertilizer at seeding time has very beneficial results, and it is the standard practice to apply 1 cwt. per acre of nitro-chalk at sowing time or immediately afterwards to all the new swards. All the improved areas receive a further dressing of phosphatic manure in their second or third years, which is given in the form of 6 cwt. per acre 58 per cent. total phosphates of finely ground gafsa phosphate. This enables almost double the amount of phosphoric acid of the initial dressing to be applied at the same cost for transport and distributing. At this latter stage the absence of free lime in the dressing would seem to be of less practical importance than in the initial dressing.

Experiments with potash manures have yielded somewhat inconclusive results, and while excellent results have been obtained with dressings of lime, the cost of transport and distribution of worth-while dressings would seem to be uneconomic on hill land. At the same time, dressings of only 5 to 10 cwt. appear to assist materially the establishment and persistency of the better grasses such as perennial rye-grass, crested dogstail, and cocksfoot.

Seeding.

After ploughing the seeds mixture is sown sometimes with a nurse crop of rape and/or turnips, but after other methods of cultivation the seeds mixture is, of course, sown alone.

The most important constituent of any seeds mixture for hill improvement is wild white clover, and for most purposes seedsmen's cleanings of that plant are usually employed. Owing to their weed content these cleanings are unfit for use under lowland conditions, but under hill conditions this seems to be of little importance. In fact the commoner weeds found in clover cleanings, such as ribwort and daisy, have a high mineral content, and in consequence are of very great value in hill swards. The composition of the remainder of the mixture depends to a large extent on the type of land to be sown and the number of

years it is intended to leave the pasture down. Probably the best procedure is to sow a fairly cheap seeds mixture after drastic harrowing or rotary cultivation, and after an interval of three or four years, during which the clover will have built up soil fertility, to plough up and re-sow with a first class mixture of pedigree seeds. It is important to remember that the poorer the land, the higher must be the seed rate. Normally, on fairly good hill land, the seed rate employed is as follows :—

	Lb. per acre
Wild white clover cleanings	6—8
Indigenous perennial rye-grass cleanings ...	24—30
Crested dogstail cleanings	6—8

On the poorer types of land, Yorkshire fog is included at the rate of 4 to 6 lb. per acre.

On moderately good land this mixture is usually reinforced by the addition of 6-8 lb. each of grazing strains of pedigree perennial rye-grass and perennial cocksfoot. On peaty or boggy land the cocksfoot is replaced by 5 lb. of pedigree timothy.

Fattening crops.

On some conveniently situated and fenced in areas one or two, or more, fattening crops are taken before finally laying down to permanent grass; quite good crops have been grown at altitudes ranging from 1,000 to 1,300 feet. Rape and hardy green turnips are sown at the rate of 2 and 3 lb. per acre respectively; sometimes with the permanent seed but more often with Italian rye-grass, which, after the fattening crops have been grazed off, provides extremely valuable winter keep. Rape, when a good crop, provides more bulk than turnips, gives a better fattening rate, and has proved more palatable to lambs. Turnips are, however, a very much more certain crop under hill conditions, and in the seedling stage are much less susceptible to damage by wood pigeons. Kale, sown both broadcast and in rows, has also been tried as a fattening crop, but it seems to demand a higher standard of fertility than is usually obtainable under upland conditions.

Records and weights of lambs fattening on these crops have been kept, and some interesting results obtained. Live weight increases of from 50 to over 200 lb. per acre have been recorded. No. 9*b* Prignant has been cropped with rape and turnips for three successive years, and the 1936 yield is the best yet obtained, over 206 lb. live weight increase of lambs per acre. Small scale lamb fattening trials have been carried out and reported on (1).

Wintering.

The problem of wintering is one of the principal questions confronting hill farmers and a number of trials testing out various crops and methods have been tried out. For instance, a 12-acre field has been cropped for four years with Strigosa oats, cut green for forage in July or August, and Italian rye-grass. After harvest, the Italian rye-grass is dresseed with 1 cwt. per acre of nitro-chalk and used most successfully for wintering weakly hill ewes. Pedigree timothy grown in rows to which the ewes are allowed access for 1½ to two hours daily, spending the remainder of the day on adjoining rough pasture, have also proved very valuable in the above connection. Lambs have also been wintered on this two-hour system on the timothy rows, and it has been estimated conservatively that seven acres of these rows, together with nine acres of rough adjoining pasture, will winter successfully seventy Welsh mountain yearlings(2).

In addition to the above, the wintering capacity of the new swards on the hill has been noted. A block of 31 acres of which 28½ have been improved, has successfully wintered for two years seventy Welsh ewes. Another block at a lower elevation, on what was previously a bracken infested bank, has consistently wintered three ewes per acre(3). The timothy rows are in Field No. 3 Pwllpeiran, and the oats and Italian rye-grass in Field No. 5 Pwllpeiran.

Stocking.

Sheep are of necessity the principal stock of any hill farm and a flock of some 2,000 is kept at Nant Rhys, while at Prignant there is a small flock of an improved type of Welsh mountain sheep. Pwllpeiran hill carries no flock of its own; it is used in summer for fattening lambs on their dams and in winter for grazing weakly ewes drafted down from Nant Rhys. As the Scheme only farms some 100 acres of fields of poor quality and at high elevations, nearly all the ewe lambs are sent down to the lowlands for wintering. In past years large numbers of sheep have also been wintered away, but the winter carrying capacity of the improved swards has increased so rapidly that a great many more sheep are now wintered at home.

In order to manage the new grazing properly it is necessary to graze a fair number of cattle and/or ponies in summer. With this purpose in view, a small herd of pedigree Welsh Black Cattle have been established and these are used chiefly as scavengers, grazing after the sheep on the improved swards and on the marshes in summer. Whereas under the old system only mature

cattle would thrive on the hill in summer, it has been shown that yearlings of ten months and over can be successfully summered on new pastures at elevations ranging to over 1,350 feet. A small stud of Welsh mountain ponies is kept for the same purpose. It is intended to cross these with an Arab stallion to produce a more popular type of riding pony.

The working horses consist of two Welsh cob mares and one half-bred mare. These horses are active and hardy, and very useful for hill work. A number of riding ponies is kept for use by shepherds, etc.

Implements.

The track-laying tractor is essential for hill improvement work and the Scheme possesses a 20 h.p. petrol-driven Caterpillar tractor. It has given excellent service, having worked over 4,000 hours without any major troubles. A good complement to the Caterpillar tractor, which cannot be legally used on the roads, is the pneumatic tyred Fordson tractor which has proved extremely useful for road haulage, harvesting, and field work on the less steep areas. This machine has given good trouble-free service.

Of the other implements, there were none specifically designed for this type of work, with the result that a large number of improvisations had to be tried out. Some account is given below of those implements used essentially for hill work as opposed to those employed principally for the ordinary routine work of the farm.

A number of both disc and mould-board ploughs were tested out, and though the very heavy type of disc plough stood up to the work fairly well, it did a very rough job. The best plough by far for this type of work has proved to be the Ransome Junotrac 2-furrow 14-inch plough. Though this implement has ploughed a large acreage of open hill and boulder strewn fields, only a few minor repairs have been necessary.

Rotary cultivation work has been carried out by two machines, the Austral and the Fishleigh. The Austral has a number of knives bent at right angles which cut up the surface into clods, about six inches in size. It is bolted on to the back part of the tractor, forming one unit with it. This is of considerable advantage in negotiating hill slopes or cultivating soft peaty land. The Fishleigh, on the other hand, is pulled by the tractor on its own wheels and, instead of knives, has numerous tines which tear up the mat and top layer of soil. The tearing action of the numerous tines leaves the cultivated surface in a finer

state of disintegration; it is much more easily dealt with than the clods formed by the knives. The Austral has been used on the great majority of the rotary cultivated areas on the hill.

Numerous types of harrows have been tried out, ranging from very severe types such as the Pitchpole, New Zealand Whakatane, Aitkenhead, Howard Dagger, Nicholson's Star Turn and Bamfords Grassland Rejuvenator down to the old moss harrows. Many of these have been tried both alone and in combination, but so far none has proved severe enough in action, though doing good work under less severe conditions.

All these harrows will be familiar to British agriculturists, with the exception of the New Zealand Whakatane. This is a flexible steel harrow, the tines being hinged on to a cross-sectioned frame. The actual tines are about five inches long and bent so as to form an acute angle with the ground. The drastic action of the harrow is strengthened by special treatment of the tine tips with manganese. This harrow is exceptionally useful, and because of its very simple construction is capable of withstanding a great amount of hard work, even on boulder-strewn hill pasture.

In addition to the foregoing, a Ransomes rotary scraper has done excellent work in clearing ditches, ponds, etc., and in making roadways. A Howard grader has also been of great service in making and enlarging mountain roadways, for which purpose it has been used in conjunction with the Junotrac plough.

Grass Drying.

In collaboration with Messrs. Kalodol Burners, Ltd., and the Anglo-American Oil Company and Messrs. Shell-Mex B.P. Ltd., a portable crude oil drier is at present installed at Pwllpeiran, and some of the dried grass produced is being used for wintering trials this season. The improved hill does not lend itself to drying, principally because of steepness, but good material for drying has been obtained from temporary and permanent lowland swards. In one case a field sown down with permanent mixture in the middle of May, 1936, and lightly grazed six weeks later, was cut for drying in late August.

The plant in question is a two-stage drier, the first stage being carried out in a large hopper through which the hot air passes immediately after it has left a revolving drum of thick wire mesh, situated directly below the hopper, in which the final drying stage is carried out. The partially dried grass is dropped through trapdoors from the hopper to the drum, which operates

at about 8 r.p.m., and is fitted with baffle plates which ted the drying grass and so prevent wet patches in the finished product. The heat is generated in a circular brick lined furnace fired by twin burners fed with crude oil under low pressure. The motive power for drum and fan is derived from a 6 h.p. Lister paraffin engine. A hay elevator operated by electricity is utilized for loading the wet grass into the hopper, and with this in use the whole plant can be operated by one man.

Rush and Bracken Eradication.

Important aspects of hill improvement work not yet mentioned in any detail are the reduction and eradication of bracken and rushes. In three years the following method has reduced the bracken infestation of a very badly overrun hill paddock by at least 80 per cent. The area was ploughed in spring, and subjected to drastic harrowing and cultivation when the young bracken shoots, coming up through the plough, were in the curled stage. Subsequently the bracken was cut twice annually, though in the fourth year only one cutting was necessary as by then the bracken was reduced to an almost negligible quantity. Unploughed areas have also been dealt with, but the reduction in bracken, though considerable, has not been at the same rate as on land ploughed and seeded. Various chemical treatments of bracken have been tried out, but at present, cost is a limiting factor to their value. The most effective chemical treatment has been an application of sodium chlorate at the rate of 1½ cwt. per acre, but here again the cost is at present prohibitive.

Experiments in rush eradication have also been carried out, and one particular block of intake has been treated most successfully on the following lines. During the summer of 1933 the rushes were twice mown over and collected for bedding. During a frosty spell in winter the rushes were again cut over, and after drastic harrowing the area was sown in spring, 1934, with six cwt. per acre of basic slag and wild white clover seed cleanings. The area was again twice mown over in summer for the two subsequent seasons, and by 1936 the rushes were so reduced that only one cutting was necessary. The herbage shows a very marked improvement with a great increase in wild white clover.

General Policy.

The scheme has now been in operation for nearly four years, and during this period the policy has been to improve the

maximum amount possible of the hill grazings that are amenable to improvement.

The sheep flock as taken over at Nant Rhys was 1,840 ewes and 400 lambs, a figure too high for the summer capacity of the land and far too high for it to winter successfully. In consequence, a large number of sheep had to be drafted down every winter and many wether lambs had to be fattened. The policy in the past, therefore, has been to grow a considerable acreage of fattening crops, together with Italian rye-grass for use subsequently as winter keep. In addition to home bred lambs, a large number of lambs have been purchased annually for fattening on these pastures. During the 1935 season 1,234 fat lambs and wethers were fattened on the Scheme's lands and sold fat in Manchester, Liverpool and Birmingham.

The main object of this process was to increase the fertility of the reclaimed paddocks prior to sowing them down with a good permanent mixture, but now, owing to the increase in the Nant Rhys flock, only small areas of fattening crops will be grown, and the lands will be managed primarily with a view to obtaining from them the maximum amount possible of winter keep.

Acknowledgement.

The writer desires to acknowledge the helpful criticism and advice of Professor R. G. Stapledon, C.B.E., M.A., Director of the Cahn Hill Improvement Scheme, in connection with the preparation of this report.

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THE WINTERING OF SHEEP AT HIGH ELEVATIONS.

By Moses Griffith, M.Sc.,
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and
P. M. G. Hutton, Dip.Agric. (Wye).

The extension this year of the wintering trials in progress under the Cahn Hill Improvement Scheme to include the experimental feeding of dried grass to hill ewes renders opportune a review of such methods of wintering as have already been the subject of examination. These trials were instituted with a view to mitigating, if possible, the very heavy annual charges payable by hill farmers through the necessity for wintering away a large proportion of their young stock.

The object of this annual migration of young stock is threefold. Firstly, the necessity for a reduction in stock carried during the critical minimum growth period of the year; the young stock are chosen for removal because in their case a lack of keep, coupled with adverse climatic conditions, would result in stunted growth and high mortality. Secondly, the wintering away period coincides with the stage of critical growth in the young animal, the body framework of a hill sheep being formed mainly in its first year. From birth to weaning the lambs invariably obtain milk in some quantity, however small. This small amount of calcium-efficient food enables fair growth to be maintained even on poor hill land, definitely deficient in lime. Wintering away on cultivated fields, that is, on minerally-efficient herbage, ensures the continued absorption into the system of bone-forming materials during the whole of the first twelve months of the animal's life. Among the older farmers it is sometimes held that the great reduction in liming of lowland pastures in recent years has brought about a deterioration in the amount of growth made by the yearlings wintered on them as compared with that produced forty or fifty years ago when heavy liming was the prevalent practice; this, notwithstanding the constructive attempts now being made to improve the general conformation of hill sheep. Thirdly, when the younger in-lamb ewes are wintered away, the necessary handling and travelling, together with the unfamiliar environment at lambing time, almost invariably cause a heavy drop in the lambing average.

In Mid-Wales it is customary to send the yearlings down to lowland pastures during the second or third week in October, leaving them there until mid-April. If casual inspections were to be made at the times of departure and return it would appear that the sheep had increased considerably both in size and weight. Nevertheless figures obtained during the last three winters prove conclusively that an increase in weight is only recorded in the most exceptional circumstances, a small loss, in the neighbourhood of one or two lb. per head, being the usual result; the highest average loss yet recorded for any one farm being slightly under 9 lb. per head. The bigger appearance of the lambs is found to be due to considerable growth of the frame, their condition being actually very much thinner.

The important place occupied by this problem in the general economy of hill farming has caused the Cahn Hill Improvement Scheme to test the value of various methods of upland wintering such as the provision of new hill swards of good botanical composition and the growing of special minerally-efficient crops, such as pedigree timothy grown in rows, and Italian rye-grass sown broadcast with a cover crop of oats. These methods have already been the subject of previous articles and a brief resumé of the results obtained to date is given below. The interested reader is referred to the various references for fuller information.

At a Grassland Conference in 1928 Professor Stapledon drew attention to the possibility of evolving a system of wintering sheep under which the animals would be grazed for approximately two hours per day on young winter-green, minerally-efficient herbage, spending the remainder of the twenty-four hour period on rough pasture. This suggestion was first tested out at Egryn, Merionethshire, in 1929, when a three-acre field was sown in April with three plots of Italian rye-grass. A light crop of hay was taken from two plots in summer and twenty wether lambs were fattened on the remaining plot, this plot only having been sown with rape as a cover crop. Grazing was carried out on the above system from 27th December to 5th April, at which time about half the original herbage remained ungrazed, and it could be stated authoritatively that the three acres of Italian rye-grass, together with rough adjoining pasture, would have provided adequate keep during this period for forty Welsh lambs (1).

The Cahn Hill Improvement Scheme took possession of its lands in March, 1933, and from the beginning this question of winter keep has been regarded as one of paramount importance. During May of 1933 seven acres of land were sown with pedigree

timothy in rows, broadcasting of this species being considered undesirable, and a twelve-acre field was sown with Italian rye-grass together with a cover crop of oats. During the winter of 1933-34 these areas were grazed on the two-hour period system in conjunction with adjoining old pasture and mountain land, and the results obtained enable it to be stated that the seven acres of timothy rows, together with nine acres of rough pasture adjoining, would keep seventy Welsh lambs throughout the six months of winter. Satisfactory results were also obtained from the Italian rye-grass area, though owing to the crop being greatly reduced by drought, these were not so striking as those obtained from the timothy rows (2).

In the winter of 1934-5 the timothy rows were again grazed on the same principle as in the previous year, and again most encouraging results were obtained, confirming those of the previous year (3). In the summers of 1934 and 1935 light crops of good quality hay were obtained from both the timothy and Italian areas, and in October, 1933, A.I.V. silage was made from a cut-over of the timothy rows.

In the second winter it was considered, however, that the Italian rye-grass which had been re-sown with a cover crop of oats for forage, could most usefully be employed to promote the recuperation of weakly in-lamb ewes which were drafted down in periodic batches from the minerally inefficient pastures of the open mountain sheep-walk. After a few days on the Italian rye-grass the sheep regained their normal vigour in a most striking manner. In the winter of 1935-6 the Italian rye-grass, again re-sown, was used for the same purpose with similar results. In this connection the wintering value of Italian rye-grass, together with its potential use as a fattening crop (4) make it of very great value in any system of improved hill farming.

It should be stated here that in both 1934-5, and in 1935-6, the weight and condition of these home wintered lambs were recorded and found to compare most favourably with those for similar batches of lambs wintered away in the lowlands in the usual manner.

In the winter of 1935-6 it was decided to test out the value of the timothy rows as a means of providing weakly ewes from the hill with one good feed per day of minerally efficient herbage. A number of young, very poor and weakly in-lamb ewes was drafted down from the open hill in late February, the last gathering of the season, and on the 21st of February, 1936, two batches of seventy-five each commenced grazing on cultivated pastures.

One batch was turned to an old pasture adjoining the timothy rows which they grazed for two hours daily; the other group to an old nine-acre meadow, containing a good deal of keep, in addition to which they received ten ounces of maize per head per day. These two groups responded very differently to their respective treatments. During the first few days a distinct difference was noted in the timothy grazed ewes; their increasing activity and sharpness being in marked contrast to the maize-fed sheep. After four weeks the former looked so strong that it was decided to turn them back on to the hill so as to permit of their replacement by a further batch of weakly ewes. Almost every ewe in the timothy group reared a lamb successfully, whereas those receiving maize returned a lambing average of about 75 per cent. only. During the four weeks' period under review the two lots of sheep were weighed and the results of these weighings are given in Table I.

TABLE I.

Date of weighing.	*Average weight per ewe in pounds.*	
	Timothy group.	*Old meadow and maize group.*
1936.		
February 21	50.0	49.8
March 6	54.0	48.0
March 21	58.5	53.2

The newly sown swards on what was, in the majority of cases, previously open sheep-walk, have also been used successfully for wintering, and the first block to be cultivated when the scheme commenced operations can usefully be taken as an example of the wintering capacity of these new pastures. This block comprises 31.5 acres, of which twenty-eight were cultivated in April, 1933, and sown down with wild white clover and grass cleanings. This block was grazed during the summer and wintered seventy ewes for the period mid-October to early May, the sheep being on the area for the whole time except for an enforced absence of a few days occasioned by a very severe snow storm. The same number of ewes was wintered during 1934-5, and in both years the ewes did well, rearing good crops of healthy lambs. This improved sward carried during the summer four ewes and their lambs per acre up to weaning time in August. According to various reports the carrying capacity of this block prior to improvement was one ewe and lamb per acre in summer

and very much less in winter (5). Another block at a lower elevation, a steep bracken-infested bank, eight acres in extent, of which seven acres were horse-ploughed in 1934 and sown down under rape with a permanent mixture of good quality grasses and wild white clover, has consistently wintered three ewes per acre.

The whole question of wintering is linked up closely not only with altitude and quality of herbage but also with climatic conditions. It is of the utmost importance that the sheep be allowed access to lands sheltered from the prevailing winds. In one instance on Pwllpeiran hill an improved pasture containing plenty of keep, but in an exposed position confined to one slope, while being used for wintering ewes caused, during a period of severe storms, obvious symptoms of suffering from exposure and considerable loss of weight in the ewes. Similarly a batch of lambs being wintered on the most exposed block yet improved, ranging from 1,200 to 1,350 ft. above sea level, showed signs of sluggishness and stiffness during a period of exceptionally severe weather, during which a very strong and bitterly cold east wind was blowing persistently for over a fortnight. On being removed to a more sheltered position the lambs very quickly recovered, the symptoms described disappearing rapidly.

On the other hand a big block at an elevation almost similar to the one mentioned above has been cultivated on all its slopes, and so offers improved swards facing every direction. It is very noticeable that the sheep invariably graze according to the direction and intensity of the wind. The great bulk of the Scheme's improvement work has been carried out at elevations ranging from 900 to 1,300 ft., and wintering stock thrive well when quality of pasture and aspect are good and not too confined respectively. Hence one reason for the unwillingness of hill farmers to fence mountain land and the necessity for great care in planning boundaries on hill farms.

The following figures are from analyses of herbage at Pwllpeiran kindly carried out by Professor T. W. Fagan, M.A., of the University College of Wales, Aberystwyth. The marked superiority of the improved species in essential constituents for the wintering of young stock, phosphoric acid, protein and lime, is clearly indicated.

The statement gives some idea of the general lines of the work on the wintering of hill sheep which is in progress under the Cahn Hill Improvement Scheme, but it must of necessity take a number of years to test out fully the effects of these methods on the sheep. On the advisability of hand feeding hill sheep, other than with

	Timothy rows. Per cent.	*Italian rye-grass after nurse crop.* Per cent.	*Improved sward (hill)* Per cent.	*Adjoining unimproved hill sward.* Per cent.
Crude protein including true protein	21.08	16.19	18.90	7.08
Phosphoric acid	0.76	0.54	0.85	0.16
Lime	0.51	0.59	0.55	0.20

hay, opinion is sharply divided, and, so far as is known, no concrete experiments on this aspect of the wintering question have yet been carried out.

It is necessary carefully to watch not only the subsequent progress of the ewes themselves, both on the open hill in summer and when wintered, as most of our sheep have necessarily to be, on the natural unimproved open sheep-walk, but also the health and vigour of their progeny.

Acknowledgments.

We desire to express our thanks to Professor R. G. Stapledon, C.B.E., M.A., Director of the Cahn Hill Improvement Scheme, at whose instigation these trials were begun and under whose direction they have been carried out. Thanks are also due to Mr. Gwilym Evans, M.Sc., for his supervision of the seeding of the timothy rows.

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SALES OF VARIETIES OF "SEED" OATS BY FARMERS' CO-OPERATIVE SOCIETIES IN WALES.

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In an earlier paper (Jones, 1935) an account was given of a preliminary survey of the quantities of "seed" oats sold by Farmers' Co-operative Societies in Wales. This survey was in the nature of an initial inquiry and was based upon the returns of sales for the single year 1933. It was then recognized that further data were desirable in order that the average proportions of varieties sold over several seasons could be ascertained. The survey therefore was repeated for the years 1934 and 1935. The results of the latter are given in the present paper, in which they are discussed in relation to the returns for the single year 1933.

I am deeply indebted to Mr. Hugh James, B.A., Secretary of the Welsh Agricultural Organization Society, for sending out the necessary inquiry forms and for collecting the data; and to the managers of the Societies, without whose assistance and co-operation the survey could not have been carried out, for their willing co-operation in supplying the information required; also to Miss Rhoda Peter Jones, B.A.[1] for translations of the foreign literature and for reading proofs for the press.

Although there are many varieties of spring sown oats on the market, and new ones are being added from time to time, only a comparatively small number are sown to any large extent. Those most generally grown in Wales differ widely in important characters, such as size, weight, colour and quality of the grain, also in fineness or stoutness of straw, proportion of grain to straw, in tillering capacity and in time of ripening. On account of these sharply contrasting differences in type, the suitability of particular varieties to soils and districts which vary in productive capacity differs to an appreciable extent. Some of these varieties give highest relative yields under conditions of low productivity, some under high, while others excel under conditions intermediate between these extremes. It is generally recognized that no single varietal type gives superior yields compared with others over the wide range of conditions under which oats are grown in Wales, and experimental evidence gives support to this view (Jones, *loc. cit.*).

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Apart from differences in adaptability and yield under different sets of conditions, choice of variety is also influenced by the particular requirements of the farmer. These will depend upon his system of farming and his needs with regard to grain or straw or both. Other considerations may be held in varying importance. If the farm is situated in a late district a farmer may, in order to obtain earlier harvesting, choose to grow an early maturing variety, even if this gives a slightly lower average yield of grain or straw. While in certain districts straw yields may be plentiful or even excessive to the point of lodging, in others straw growth with certain varieties may be deficient and farming requirements have to be met by resort to essentially straw-producing types. The continued survival in Wales of the old land varieties Black Tartarian, Scotch Potato, Radnorshire Sprig, *Ceirch-du-bach* and *Ceirch Llwyd* (*Avena strigosa*), which differ from the newer varieties mainly in their better adaptability to soils of medium and low productive capacity and in their ability to give high yields of good feeding straw, is evidence of the undoubted value of these varieties to meet specific agricultural demands. In addition to their crop yields these varieties have the capacity to maintain, under adverse conditions, a denser plant establishment throughout the growing season than most of our newer forms, thereby ensuring a more complete suppression of weedy undergrowth and generally less variability in crop yields from year to year. Moreover these varieties are capable of giving a high proportion of reasonably well filled germinable grain in the seed sample, and thereby lower farming costs by the reduced necessity for frequent changes of seed. This is an important item in hilly districts where exchange of seed with neighbouring farmers brings little advantage and where supplies of good seed of the same variety are not easily and cheaply obtained, for in the contiguous lowland areas the newer heavier grained varieties only would be more generally grown. Possibly the large supplies of Scotch Potato oats from Scotland which annually find a ready market in certain upland areas in Wales, and particularly those remotely situated from seed growing areas, are not wholly unconnected with this latter factor.

This survey of sales of seed oats was designed to acquire information as to what varieties were in chief demand by the Welsh farmer, their relative proportions and general geographical distribution. Evidence of this kind was considered desirable and useful as a background to the work of breeding new varieties.

To provide such evidence the survey admittedly has certain

limitations inasmuch as it covers but one section of the seed distributing organization in Wales, and therefore depends upon the representative nature of these sales. It also does not account for sales of seed between farmer and farmer, and as an index of the relative areas grown of the different varieties it does not give any measure of possible differences in the frequency with which changes of seed are required on farms growing medium or poor land varieties as compared with the frequency on farms of higher fertility where more advantageous conditions for seed ripening exist. It is possible, therefore, that the demand for seed of varieties suitable for medium and low fertility conditions is greater relative to the areas actually sown than is portrayed by their comparative sales. A fully established answer to this question can, however, only be obtained by comparison of results based on a random sampling survey of the actual areas grown of each variety.

General Details of the Survey.

Statements of sales were obtained from thirty-seven Societies. Calculated on a basis of a seed rate requirement of 200 lb. per acre the recorded sales represent a seed supply equivalent to that needed to sow approximately 8 per cent. of the total acreage devoted to oats in Wales (including Monmouth). This acreage is based upon the area under oats in 1933 (Agricultural Statistics 1933). The distribution of the Societies on a county basis is as follows :- -

Anglesey.

Foel Agricultural Co-operative Society.
North-West Anglesey Co-operative Society.

Breconshire.

West Breconshire Farmers' Association.

Cardiganshire.

Blaenpennal and District Agricultural Co-operative Society.
Vale of Tivy Agricultural Co-operative Society.
Llandyssul Agricultural Society.
Llanybyther Agricultural Co-operative Society.
North Cardiganshire Farmers' Co-operative Society.
Vale of Aeron Agricultural Society.

Carmarthenshire.

Carmarthen Farmers' Co-operative Society.
Pumpsaint and District Agricultural Co-operative Society.
Clynderwen and District Farmers' Association.
Llanelly and District Farmers' Society.

Llangadock and District Agricultural Co-operative Society.
Emlyn Agricultural Society.
Farmers' Ltd., Ammanford.
Llandovery and District Agricultural Co-operative Society.

Caernarvonshire.

Eifionydd Farmers' Association.
Clynnog Fawr Farmers' Association.
Nant Machno and District Agricultural Co-operative Society.

Denbighshire.

Llanrwst and District Agricultural Co-operative Society.
Dyffryn Ial Agricultural Co-operative Society.

Flintshire.

Vale of Clwyd Farmers' Association.

Glamorganshire.

Mid Glamorgan Farmers' Association.
West Glamorgan Farmers' Association.
Swansea and District Farmers' Association.
Pyle and District Agricultural Co-operative Society.

Merionethshire.

Dolgelley Farmers' Association.
Corwen and District Farmers' Association.
Llanbedr and Dyffryn Agricultural Co-operative Society.
Edeyrnion Agricultural Co-operative Society.

Monmouthshire.

Chepstow Farmers' Association.

Montgomeryshire.

Wynnstay Farmers' Association.

Pembrokeshire.

Haverfordwest Agricultural Co-operative Society.
Crymmych and District Farmers' Association.
Pembroke and District Agricultural Co-operative Society.

Radnorshire.

Penybont and District Farmers' Association.

Analysis of Data.

An analysis of the varieties marketed and their proportions grouped according to grades are given in Table I on a percentage basis for the years 1934 and 1935. The corresponding figures for the year 1933 are given for comparison and for determining the three-year average.

TABLE I.

Varieties.	*Grain Colour.*	*1934*	*1935*	*1933**	*Average 1933-5*
Grade I:					
Victory .	White	26.5	29.3	31.4	29.1
Abundance	,,	7.6	7.8	7.8	7.7
Golden Rain and Goldfinder†	Yellow	4.6	4.8	5.4	4.9
Supreme	Black	6.9	8.9	4.2	6.7
Record	White	2.2	0.8	1.8	1.6
Superb .	,,	0.8	0.2	1.5	0.8
Yielder .	,,	1.1	1.0	1.2	1.1
Total ..		49.7	52.8	53.3	51.9
Grade II:					
Scotch Potato	White	18.1	17.3	16.1	17.2
Castleton	,,	5.7	7.5	9.5	7.6
Radnorshire Sprig ..	Black	7.9	4.7	8.2	6.9
Black Tartarian	,,	10.9	10.7	6.7	9.4
Total ..		42.6	40.2	40.5	41.1
Grade III:					
Ceirch-du-bach	Black	5.2	5.2	3.5	4.6
Ceirch Llwyd	Grey	2.4	1.8	2.6	2.3
Total ..		7.6	7.0	6.1	6.9
Sum Total ..		99.9	100.0	99.9	99.9

* Quoted from *Ann. App. Biol.*, 1935, XXII, No. 2, p. 218.
† Mainly Golden Rain II.

The grouping of the varieties into Grades I, II and III is based upon their general suitability to soils of high, medium and low productive capacity respectively (Jones, *loc. cit.*)

A comparison of the yearly sales shows that the same varieties were marketed in the three consecutive seasons. The average proportions of each show only slight fluctuations from year to year with the exception of Supreme and Black Tartarian in 1933 and Radnorshire Sprig in 1935. On examination of the individual returns it was found that the 1933 survey did not include returns from one Society which in 1934 and 1935 sold relatively high proportions of the first two varieties, while the low proportion of Radnorshire Sprig in 1935 is mainly attributable to a like cause. Apart from these exceptions, the figures are in fairly close agreement from season to season. To what extent this is due to a rigidity of the supplies offered, or to a traditional demand by the farmer, it is not possible to say. Marvellous was included in the sales of one Society in North

Wales in 1934-5. The amount sold was very small, and it has therefore not been incorporated in the general data.

The outstanding features of the sales, taken as a whole, are firstly, the high proportions of the older varieties (Grades II and III) still being sown, more especially Grade II varieties, and secondly, the supremacy of Victory in the Grade I group and of the Potato class (Scotch Potato and Castleton) in the Grade II group which account for 29 and 24 per cent. respectively of the total sales.

Geographical Distribution.

The recorded sales, although distributed over all the counties, cannot, however, be accepted as a random sample of the seed oat sales of Wales as a whole. The location of the Societies shows a clustering in number in certain counties, and a sparsity in others. This is discernible above in the grouping of the Societies on a county basis. Its effect is more apparent when the recorded sales are separately expressed as a percentage of the oat area for each county. These percentages are shown in line 1 of Table II. The five counties of Anglesey, Denbigh, Flint, Montgomery and Radnor are very inadequately represented, the sales being less than 5 per cent. of the respective county oat areas. The sales are more comprehensive for the remaining counties and range from 5 to 39.0 per cent. These latter may be accepted as being sufficiently large to permit of a detailed examination of the kind of varieties sold by Societies in these areas.

In the same Table an analysis is given of sales on a varietal basis for each county. The figures are calculated on a basis proportionate to Victory at 100 and are given to the nearest whole number. The data are based upon the average sales for the years 1933 to 1935. In one or two instances where the returns were not available for more than two seasons the missing season is taken as being equal to the average of the two other seasons.

The figures are of considerable interest with regard to the popularity of certain varieties and their geographical distribution. In the interpretation of the data, however, it is necessary to bear in mind that the sales for Societies located in a specific county do not in all cases coincide with the county boundary. This more especially applies to the county of Carmarthen, where they overlap the county boundary and extend into adjoining territory of Pembroke, Cardigan and Brecon. It results from the location of certain Societies near the borders of the adjoining counties. The extent of the overlap is partly reflected in the high figure

TABLE II.

	Carmarthen	*Glamorgan*	*Merioneth*	*Caernarvon*	*Cardigan*	*Monmouth*	*Brecon (West)*	*Pembroke*	*Flint*	*Radnor*	*Montgomery*	*Denbigh*	*Anglesey*
Recorded sales as per cent. of county oat area	39.0*	9.9	9.6	8.5	8.2*	5.7	5.5	5.0	3.4	2.4	1.6	1.5	0.9
Grade I Varieties:													
Victory	100	100	100	100	100	100	100	100	100	100	100	100	100
Abundance	24	104	8	1	9	107	10	15	35	186	—	53	—
Golden Rain and Goldfinder †	8	—	60	29	51	—	26	—	—	190	—	24	17
Supreme	33	7	12	2	1	100	—	57	—	—	11	7	—
Record	2	1	32	5	10	—	—	2	—	—	14	5	—
Superb	3	—	—	—	—	—	—	—	—	—	—	—	—
Yielder	2	—	21	—	5	—	—	14	—	—	—	12	—
Grade II Varieties:													
Scotch Potato	57	35	470	19	105	—	88	2	—	11	145	71	2
Castleton	6	—	—	—	191	—	—	—	—	—	—	—	—
Radnorshire Sprig	19	—	—	—	29	81	397	9	—	59	—	—	—
Black Tartarian	39	59	21	3	—	—	—	99	—	133	—	13	6
Grade III Varieties:													
Ceirch-du-bach	13	—	—	1	68	—	—	40	—	—	—	—	—
Ceirch Llwyd	6	1	28	1	46	—	—	—	—	—	—	—	—

* Includes certain sales which overlap the county border.

† Mainly Golden Rain II.

for recorded sales, which represents 89 per cent. of the total oat area. A high proportion is, however, expected in this county since the Societies here account for the major part of the trade in seed oats. There is also a relatively high yearly demand for seed oats, due to the large extent to which the crop is grown for fodder purposes and is fed to stock unthreshed.

Grade I Varieties.

This group comprises all the newer varieties of oats recorded in the sales. They are essentially grain-producers and compared with varieties of the other groups the grain is large and heavy. Within the eight counties brought under detailed consideration Victory is pre-eminent in having the widest distribution. In this respect, as well as in the proportion of seed sold, it is the outstanding member. With the exception of Glamorgan and Monmouth its proportionate county sales are markedly higher than those of any other variety within the group. In Glamorgan, Abundance has a very slightly higher sale, while in Monmouth, Victory shares its leading position with Abundance and Supreme on almost equal terms.

The distribution of the other varieties is distinctly localized. Thus Abundance is sold on an appreciable scale only in Glamorgan and Monmouth, where, as already mentioned, it competes on an even basis with Victory. It is sold to a certain degree (24 per cent. of Victory) in Carmarthen, and to a lesser extent in Pembroke. In all other counties it represents 10 per cent. or less of the sales of Victory, and less than 1 per cent. in Caernarvon.

Golden Rain attracts attention by its complete absence in the two counties (Glamorgan and Monmouth) where Abundance competes successfully with Victory, and in Pembroke. This oat shows a marked tendency towards a greater popularity in the more northerly counties of Cardigan, Merioneth and Caernarvon, where the sales relative to Victory are 51, 60 and 29 per cent. respectively. It also appears in moderate amount in West Brecon, namely, 26 per cent. In these four counties its sales in this group rank second to those of Victory.

Supreme, on the other hand, tends to dovetail with Golden Rain, being highest, 100 and 57, in those counties (Monmouth and Pembroke respectively) where Golden Rain is not sold, and lowest where the latter is in fairly good demand, for example, in West Brecon 0, Cardigan 1, Caernarvon 2, Merioneth 12, compared with Victory at 100. It is also sold in moderate amount, 38 per cent. of Victory, in Carmarthen. It should be observed here that on account of the overlap of county sales the figure for

Supreme in Pembroke should be higher and that for Carmarthen relatively lower than the figures shown in Table II. This is due to the inclusion in Carmarthen of one Society which is known to sell large quantities of Supreme to growers in adjoining areas of Pembroke.

Of the three remaining varieties in this group Record and Yielder, in Merioneth, are both in but moderate demand, in relation to Victory; while in Cardigan, Record is the more favoured of the two, and in Pembroke, Yielder. Their sales outside of these areas are almost negligible.

Sales of Superb are confined to Carmarthen and their ratio compared with Victory is as low as 8 :100.

Grade II Varieties.

The Potato varieties, although having a wider geographical distribution than the other members of group II, show marked concentration of sales in Merioneth and Cardigan, where they predominate over the other members of the group. These two counties are the stronghold of the Potato varieties. The sales of Scotch Potato in the former county are nearly five times as large as those of Victory, and exceed those of all other varieties taken together. In Cardigan, if we include the variety Castleton, the sales are approximately three times those of Victory. In Carmarthen the total sales of Scotch Potato are high, but white and black grained varieties are about equally divided. The individual records, however, show a concentration of Scotch Potato in those Societies serving the northerly and more upland areas of the county in proximity to Cardiganshire. A fairly large amount of Scotch Potato relative to Victory is apparent in West Brecon, but here Radnorshire Sprig is by far the most popular variety. Its sales are in excess of those of all other varieties, their proportion relative to Victory being as much as 397 : 100.

The distribution of Radnorshire Sprig and Black Tartarian alternate with each other. Thus in West Brecon, Monmouth and Cardigan the former is in demand but not the latter, whereas in Glamorgan, Merioneth and Caernarvon, Black Tartarian is sold to the complete exclusion of Radnorshire Sprig. In Monmouth, Radnorshire Sprig is the sole representative of the group, and a like position is very nearly attained by Black Tartarian in Pembroke. Excluding Carmarthen, Glamorgan and Caernarvon, where the sales of black and white grained varieties are relatively nearly equal, we have in this group a fairly clear-cut geographical division of the varieties. To recapitulate, in Merioneth, Scotch

Potato, in Cardigan, Scotch Potato and Castleton, in Monmouth and West Brecon, Radnorshire Sprig, and in Pembroke, Black Tartarian.

Grade III Varieties.

As in group II, a localized preference for one or other of the members in group III is apparent. The sales, however, have a narrower geographical range and are restricted almost entirely to the counties of Carmarthen, Merioneth, Cardigan and Pembroke. In the last named county the choice is solely and entirely in favour of the *Ceirch-du-bach*. Merioneth, on the other hand, gives sole preference to *Ceirch Llwyd* (*A. strigosa*). In the two remaining counties both varieties are sold, but *Ceirch-du-bach* to a greater extent than *Ceirch Llwyd*. Individual returns show that in Cardigan the sales of *Ceirch-du-bach* were mainly restricted to the southern part of the county, and those of *Ceirch Llwyd* to the more northerly area. Both varieties are marketed to a large extent in this county.

In connection with the geographical distribution of sales it should be borne in mind that the absence of sales of particular varieties in certain counties does not necessarily imply that no seed of these is sold within the area. It can, however, be accepted as highly probable that where the Society sales represent a large proportion of the county requirements, such varieties, if sold at all, are sold to a limited or negligible degree.

Distribution in Relation to Grain Colour.

In the above section the geographical distribution of varieties has been considered in relation to their popularity and distribution within the grade or group. It is known, however, that grain colour in itself is frequently a discriminating factor in the choice of variety by the farmer. There is at present little evidence to show whether colour in itself is a primary factor in determining regional distribution, or whether discrimination in favour of a particular colour is due to its association, accidental or real, with some desirable agronomic (field characteristic) feature of the variety. Quite often partiality to colour is ascribed to a traditional disposition on the part of the grower. It may, however, be associated too with the established market demands of the region and with a preference on the part of the miller or merchant. While, on the other hand, it may be purely historically related to the incidence of origin or introduction of a particular variety in a district, coupled with a restricted choice of colour in relation to the agronomic types of the earlier varieties cultivated.

In this survey of sales there is evidence of a regional distribution of varieties on a basis of grain colour.

In the southern counties of Carmarthen, Glamorgan, Monmouth and Pembroke, black-grained varieties figure more prominently than elsewhere. Within the Grade I group this is apparent in the increased relative sales of Supreme. Where Grade II varieties are in demand the choice is in favour of Black Tartarian in Glamorgan and Pembroke, and of Radnorshire Sprig in Monmouth and West Brecon. Of Grade III varieties *Ceirch-du-bach* is here chosen rather than *Ceirch Llwyd.*

In the more northerly areas of Cardigan and Merioneth whites increase, the proportion of black-grained varieties falls off and there is a penetration of yellow-grained varieties. Supreme is sold only in small amount in Merioneth, and to a negligible degree in Cardigan. Here also relatively small amounts of black-grained varieties are marketed in the Grade II group. These are limited to Black Tartarian in Merioneth and to Radnorshire Sprig in Cardiganshire. In the latter county the individual returns show their prevalence mainly confined to the southern districts. Moreover, *Ceirch Llwyd* as opposed to *Ceirch-du-bach* in the Grade III group, gains in popularity as we proceed north, and follows closely the increased preference for Scotch Potato. In Caernarvon, in the extreme north, the yellow oat Goldfinder was formerly in great demand. Its place is now being largely taken by Golden Rain II. This variety is also prominent in the sales in Merioneth, Cardigan, and West Brecon.

The non-appearance of yellow varieties in the extreme southern counties, apart from a negligible amount in Carmarthen, emphasizes the segregation of varieties on a colour basis.

In general, blacks are seen to take a prominent position in relation to whites in the south, and yellow in relation to the latter in the central and northerly areas.

The evident popularity and wide distribution of the white-grained oat Victory in Wales corresponds with a like behaviour in Sweden where, according to Granhall (1935), it has had a wide and general distribution. In Sweden at the present time, however, Golden Rain II is taking the place of Victory and has become the most widely distributed variety. Although yellow oats are represented in the central and northern counties of Wales, their occurrence in Merioneth, Cardigan and West Brecon appears to be of more recent origin than in Caernarvon. The prevalence of Golden Rain II in these areas is in some measure due to

educational activity, this variety being recommended as preferable to Scotch Potato and Radnorshire Sprig on the rather better types of soil on which one or other of these was formerly grown. Of the newer varieties in the Grade I group Golden Rain II appears to possess a better adaptability to conditions of rather lower productivity. Its somewhat earlier maturity also gives it a certain advantage under wet upland conditions, but nevertheless under adverse conditions the grain is often not very well filled and leaves room for improvement.

There are indications, however, that the popularity of Black Tartarian in the southern areas, and of Scotch Potato in the more northerly districts, apart from any traditional partiality to colour, is in some degree determined by associated physiological and morphological differences which are probably of ecological significance. A somewhat similar distribution occurs across the border. In the relatively drier south-eastern counties of England I am informed that Black Tartarian represents the chief Grade II variety grown, and that Scotch Potato is less satisfactory and is grown only to a very limited extent. Farther north, and in Scotland in particular, the latter increases in popularity. Its adaptability to certain Scottish conditions is widely acknowledged. This oat responds well to a generous rainfall during the phases of early shooting and ear emergence, and, provided no severe rust epidemic intervenes, it gives a large quantity of good fodder when grown on soils of medium fertility.

In Sweden, Granhall (1936) and Åkerman and Granhall (1935) have observed that in the central provinces black-grained varieties are widely grown. These varieties, they state, are better able than whites, especially on the stiff clay soils, to endure summer droughts which frequently occur in these areas. There it is found difficult to obtain uniform and dense crops of white oats, and the blacks withstand the conditions better on account of their slower early growth rate and somewhat better tillering capacity.

While traditional partiality to colour may play a part in maintaining a segregation of varieties on a basis of colour, it is nevertheless felt that this is due less to the colour factor alone than to the association of colour with some feature or features of agronomic importance. This is not to say that colour in itself is not of importance either in the commercial usage or geographical distribution of the variety. For, as Lewicke (1929) has shown, the mechanism of the pigmentation of the grain has a physiological influence upon respiration and metabolism which in

turn facilitate better adaptation to the external conditions. This, as he points out, may underlie the wide distribution of coloured varieties of cereals and of black oats in cool mountainous countries and under moorland conditions. Since black oats realize a lower price in the market compared with white, due partly to their narrower range of usefulness for milling purposes and partly to their generally lower grain quality, their continued cultivation is quite probably related to some underlying associated factor, accidental or real, giving these varieties a possible ecological advantage.

The Relative Proportion of Different Grades Sold.

Indications of the extent to which the three grades are in demand in different parts of Wales are afforded by a comparison of areas for which fairly large sales are recorded. Carmarthen, Glamorgan, Cardigan, Brecon and Pembroke form one large and distinct sales region which we may consider as one unit. It includes about 48 per cent. of the total oat acreage in Wales, and the recorded sales represent 14.5 per cent. of the oat area of the region. In the remaining counties the sales data are less adequate. There are, however, two counties, namely, Merioneth and Cardigan, for which the sales represent 9.6 and 8.5 per cent. of the respective oat areas, and these may be considered as separate units.

The proportionate sales of the three grades within the three regions are set out in Table III. Compared with the general averages for the total sales in Wales as shown in the last column of Table I, the grouped southern counties do not show any marked divergence. There is a decrease of three in the percentage of Grade I varieties and an increase of rather more than two in Grade II, and of rather less than one in the Grade III group. The comparative figures are 51.9, 41.1 and 6.9; 48.9, 43.4 and 7.7 respectively. This close agreement is perhaps to be expected owing to the large contribution which this area makes towards the total sales. Of importance, however, in relation to our crop husbandry is the high proportion in this large area which is occupied by Grades II and III varieties and particularly the former.[2]

[2] The comparison of sales on a weight basis is a little unfair to members of the Grade III group since, owing to their smaller grain and higher tillering capacity, less seed is required to sow a given area. The relative area occupied by these varieties is, therefore, somewhat larger than the percentage comparison indicates.

TABLE III.

Variety.	*Carmarthen, Cardigan, Pembroke, West Brecon and Glamorgan.*	*Merioneth.*	*Caernarvon.*
Grade I:			
Victory	27.2	13.3	62.7
Abundance ...	7.4	1.0	0.2
Golden Rain (and Goldfinder) ..	3.1	8.0	18.5
Supreme	8.8	1.5	1.2
Record	0.8	4.3	3.5
Superb	0.6	—	—
Yielder	1.0	2.7	—
Percentage proportion	48.9	30.8	86.1
Grade II:			
Scotch Potato ...	15.0	62.5	12.1
Castleton .	8.6	—	—
Radnorshire Sprig .	8.5	—	—
Black Tartarian .	11.3	2.9	1.7
Percentage proportion	43.4	65.4	13.8
Grade III:			
Ceirch-du-bach .	5.4	—	0.1
Ceirch Llwyd ...	2.3	3.8	
Percentage proportion	7.7	3.8	0.1
Total	100.0	100.0	100.0

Of possible underlying causes that of the system of the farming within the area is probably important. In many parts of this region, especially in Carmarthen and Glamorgan, much of the best and most productive land is under grass for dairying purposes. Cultivation of oats is in consequence restricted to fields of lower fertility and to the higher elevations. Furthermore, the crop is largely grown in the upland areas where store cattle are reared, and the produce is mainly fed to the stock unthreshed. A large bulk of fodder is a primary need, to meet which the high dual capacity of the older varieties for straw and grain production makes them eminently suitable.

The practice of not threshing out the grain leads in turn to a greater proportional yearly demand for seed oats of these varieties.

The two county units of Merioneth and Caernarvon differ very appreciably from the general average and from one another; the percentage proportion of the three grades being 30.8, 65.4, 3.8 and 86.1, 13.8, 0.1 respectively.

In Merioneth approximately two-thirds of the total sales consist of Grade II varieties, in which Potato is pre-eminent and accounts for 62.5 per cent. of the sales of all varieties. Both Grade I and III members are sold in appreciably lower amounts than in the South Wales region. In this county an extremely large portion of the oat area lies at relatively high altitudes, the soil fertility is comparatively low and rainfall rather high. Choice of variety is mainly determined by its suitability for fodder purposes, and Scotch Potato and *Ceirch Llwyd* figure as the most popular varieties grown. Much of the crop in upland districts is fed to the stock unthreshed. At the lower levels a portion is threshed for feeding to the stock as grain, and for the production of oatmeal.

In Caernarvon on the other hand the sales of Grade III varieties are negligible, and those of Grade II account for only 14 per cent. of the total. Here, owing to the lower elevation of the main part of the oat area and the wind-swept nature of the territory, the somewhat stiffer-strawed, heavy-grained Grade I varieties are in more demand and constitute 86 per cent. of the seed sales, of which Victory forms the greatest part.

This analysis of the oat sales data would not be complete without some allusion to the areas for which the returns constitute less than 5 per cent., namely, Anglesey, Denbigh, Flint, Montgomery and Radnor. These returns, as far as they go, suggest a tendency towards a higher demand for newer varieties, and it is anticipated that a more extensive survey would disclose a proportionately lower percentage of Grade II and III varieties than that existing in the southern counties.

Summary.

The oat sales investigated in this survey represent about 8 per cent. of the seed supplies necessary to sow the whole of the oat acreage in Wales. The returns from Anglesey, Denbigh, Flint, Montgomry and Radnor are meagre and represent less than 5 per cent. of the sown areas. The evidence therefore restricts the analysis of sales and their geographical distribution to the remaining counties.

Of Grade I varieties, Victory is pre-eminent and shows the widest and most general distribution : other members show a more restricted distribution ; Abundance to Glamorgan and Monmouth, and Supreme to Monmouth, Pembroke and parts of Carmarthen. The last named variety is second in demand to Victory in South Wales. In Central and North Wales the second position is taken by yellow oats, mainly Golden Rain II.

In the Grade II group, Black Tartarian predominates in Pembroke and Glamorgan; Radnorshire Sprig in Monmouth and West Brecon, and the Potato varieties in Merioneth and Cardigan. In Carmarthen the demand is wider and more general, while in Caernarvon, sales in this group are small and are confined to Potato and a little Black Tartarian.

In the Grade III group, sales of *Ceirch-du-bach* are restricted to Pembroke, South Cardigan and parts of Carmarthen, while Merioneth and North Cardigan and Carmarthen account almost entirely for the sales of *Ceirch Llwyd.*

There is evidence of a distribution of varieties on a basis of grain colour. Whites show a general distribution, while blacks are second in importance in the south, and yellow in the central and northerly counties. Its probable geographical significance is discussed.

The proportions in which the three grades were sold are as follows :—

For the whole of Wales, Grade I, 51.9; Grade II, 41.1; and Grade III, 6.9.

For Glamorgan, Carmarthen, Cardigan, West Brecon and Pembroke, 48.9, 43.4 and 7.7 respectively.

For Merioneth, 30.8, 65.4 and 3.8 respectively.

For Caernarvon, 86.1, 13.8 and 0.1 respectively.

These proportions are discussed in relation to the fertility conditions and general husbandry of the areas.

In the remaining counties, for which less representative sales were recorded, there is a general indication that a higher average demand prevails for varieties of the Grade I group than that shown for Wales as a whole.

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THE GROWING DANGER OF LIME DEPLETION IN WELSH SOILS.

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Introductory.

In an early number of this Journal (1), the writer directed attention to the problem of soil acidity and available lime in North Welsh soils. It was pointed out that the wet climate caused a continuous desaturation of soils with respect to calcium, and that many soils, which did not at that time respond to liming, were steadily losing their reserves—probably the residues of generous application of lime in bygone years. It was suggested that it might be desirable to forestall the inevitable depletion in calcium by reviving liming as an ordinary farm practice. To-day there is little doubt that the situation is much worse and many more soils show a definite deficiency in lime.

A considerable body of information on the lime-status of North Welsh soils is available at Bangor in the analyses of soil samples for advisory and survey purposes. A high percentage of the soils show lime-deficiency. The survey samples have been taken as representative of the various soils existing in the surveyed areas, and the figures, especially when considered in conjunction with those for the advisory samples, may be assumed to indicate that the majority of North Welsh soils are deficient in lime, that the general level of lime-status in the soils is low, and that it is in the course of being still further lowered.

Liming is, of course, practised to a limited extent, but, taking North Wales, or even Wales, as a whole, the loss of lime from the soil far exceeds that which is added to it. During the past few years the writer has succeeded in obtaining experimental data indicating the amount of such losses from certain North Welsh soils. As a detailed account of this work has been published elsewhere (4), only the more important results and conclusions will be quoted in the present paper; but, before dealing with them, it will be of advantage for realizing their significance to get some conception of the types of calcium compounds existing in soils.

Calcium Compounds occurring in Soils.

Calcium occurs in soils in several forms :—

(*a*) Water-soluble calcium. Usually present only in very small amounts as sulphate, chloride, and bi-carbonate.

(*b*) Calcium carbonate. Absent from most Welsh soils. It

may be present in soils derived from calcareous parent materials and occasionally, also, in soils which have received very heavy dressings of lime in the past. It should be noted, however, that soils derived from limestone frequently contain no calcium carbonate, due to its complete removal through long-continued leaching. Generally speaking, soils derived from soft limestones, such as the Lower Lias are more likely to contain free carbonate than those derived from hard limestones such as the Carboniferous.

(*c*) Calcium in combination with the weathered soil mineral matter and organic matter. This part of the soil is the reactive or colloidal fraction, and the calcium in combination with it may be regarded as the "available" calcium. Owing to certain distinctive properties exhibited by it, the term "Replaceable" or "Exchangeable" is used to designate this type of soil calcium. Not only does it serve as a reservoir of calcium for plant nutrition, but it also exerts a profound influence on the physical condition and the reaction of the soil.

(*d*) Calcium combined in unweathered soil minerals. This form of calcium has little direct influence on plant nutrition, soil reaction, and physical condition.

Soil acidity develops by the removal of exchangeable calcium and its replacement by exchangeable hydrogen; therefore, when a dressing of lime or ground limestone is applied to an acid soil, the reverse process takes place, *i.e.*, the calcium of the lime or ground limestone replaces the hydrogen, and enters the soil colloidal fraction as exchangeable calcium, thus bringing the soil reaction nearer neutrality. The amount of lime necessary to bring the soil to a certain reaction will depend on the amount and nature of the colloidal fraction, and on the extent to which the depletion of calcium and its consequent replacement by hydrogen has taken place.

The following Table illustrates the effect of dressing of ground limestone on the exchangeable calcium oxide of soils.

TABLE I.

Percentage exchangeable CaO in soil from limed and unlimed plots.

Unlimed.	*Limed.*
0.138	0.270
0.140	0.318
0.178	0.257
0.163	0.212

The above figures were obtained on samples taken from plots on a field at the College Farm. Alternate plots had received dressings of ground limestone at the rate of two tons per acre a few years previous to the sampling. The results show that in

every case the limestone has increased the exchangeable calcium oxide content of the treated plots well above any of the untreated plots. The increase in exchangeable CaO does not correspond with the amount added, owing to excessive losses by drainage subsequent to dressing. Sampling errors also affect the results.

Loss of Lime from Soils.

The exchangeable calcium content of a soil, at a given time, may be used as an indication of its lime-status, and the change in its percentage over a period of years enables the investigator to judge the rate of depletion, or loss, of calcium from the soil. The experimental data, indicating the amount of loss from North Welsh soils, to which reference has already been made, were obtained on this basis. Unfortunately, samples taken from the above plots before the addition of ground limestone were not available for analysis, so that it was impossible to study the changes in their lime status since the application of the limestone. However, it was possible to make such a study on other soils.

Samples from thirty-three fields or parts of fields were taken at the beginning and at the end of a period of years. Twenty-five of them were representative of the various types of soil at the College Farm, Aber, and eight were from fields on various farms in Anglesey. These were fairly representative of Anglesey soils from the standpoint of texture, drainage, and lime-status. The period covered by the College Farm soils was twelve years, whilst the Anglesey soils were sampled before and after eight or sixteen years. Although none of the soils from which samples were taken contained free calcium carbonate, several could be considered to be well above the deficiency line, whilst a few were definitely deficient in lime. The remainder were fairly well spread over the region between deficiency and ample supply. All these samples were analysed to determine their exchangeable calcium content.

The practical significance of the results may be more clearly estimated by expressing them in terms of weight of lime (CaO) per acre. For this purpose, it is assumed that the top layer (depth 8in.) of soil has an approximate weight of 2,000,000 lb. per acre. Thus an exchangeable calcium oxide content of 0.10 per cent. corresponds to 2,000 lb. per acre. The exchangeable lime content of the soils at the beginning of the period under consideration ranged from 8,000 lb. per acre to 9,000 lb. per acre. The principal results were as follows :—

(*a*) In general, it was found that the loss tended to be greatest in the soils with the highest exchangeable lime content.

(*b*) Little difference was to be observed in the extent of the losses when old pastures and arable soils were compared, the losses being slightly greater from the old pastures. These are shown by the summary of results in Table II.

TABLE II.

Annual loss of exchangeable CaO per acre.

Average for all soils	106 lb.
Average for College Farm soils	101 lb.
Average for Anglesey soils	118 lb.
Average for College Farm arable soils	97 lb.
Average for College Farm old pasture soils	108 lb.
Average for College Farm soils with original Exchangeable CaO above 5,000 lb. per acre	157 lb.
Average for College Farm soils with original Exchangeable CaO below 5,000 lb. per acre	75 lb.
Highest loss from any soil	224 lb.

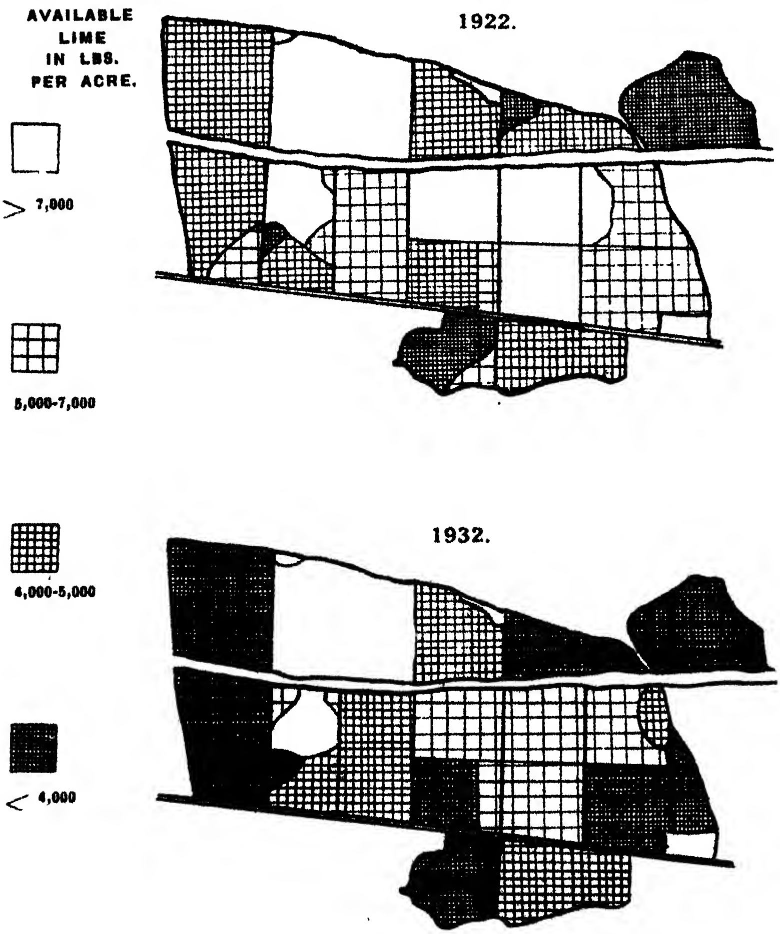
The figures presented in the above Table give a reasonable indication of the losses of lime from soils under the conditions prevailing in this part of North Wales. In districts with a higher annual rainfall the losses will probably be greater, whilst under drier conditions they will be less. The average loss for all the soils is seen to be in the neighbourhood of 1 cwt. per acre per annum.

This figure is also closely approached by the College Farm and the Anglesey soils when considered as separate groups. The annual loss of lime from a 200 acre farm on this basis would be ten tons. The figure for the College Farm soils show that when the original lime-status was fairly high the loss was greater. For those above 5,000 lb. per acre, it is twice as much as for those below this level. Experience with North Welsh soils has shown that the lower limit of satisfactory lime-status is in the region of 3,000 to 4,000 lb. exchangeable lime per acre. Soils should not be allowed to fall to this low level before applying lime. In the best interests of the farm, both for the sake of yields and to maintain quality, the exchangeable lime content of the average medium textured type of soil should not be allowed to drop below 5,000 lb. per acre, and should probably be maintained at a slightly higher level than this. Soils of a sandy type containing a smaller percentage of clay would not need to be maintained at quite such a high level. Thus, the figures suggest that, if a soil is to be maintained at a really satisfactory level of lime-status, the loss of lime per acre per annum will be slightly greater than the average figure given in Table II. It will be nearer 1½ cwt. than 1 cwt. The main cause of these losses is drainage. The analysis of a drainage water from lysimeters at the College Farm, over a period

of five years, indicates a loss through drainage of 80 lb. CaO per annum. These results are supported by similar figures (an average loss of 76 lb. per annum for an eight year period) from the Craibstone lysimeter experiments on no manure plots. The remaining loss is due to removal by crops. With such losses occurring, it is plain that soils which were, say twenty years ago, amply supplied with exchangeable lime, have by now suffered such a depletion that they are actually deficient.

The following maps, constructed from the analysis of soils from the College Farm, will show the change that can take place in the soil lime-status during a period of ten years.

Maps showing the Lime-status of the College Farm in 1922 and 1932.



For the sake of simplicity, in any fields with limed plots, the data for the unlimed portions have been used. These maps show

that some areas which ten years ago were satisfactory, are now either deficient or will very shortly be deficient in lime. They are indicated by the dark patches. If it were possible to construct a similar map for the whole of North Wales, the relative proportion of the deficient to satisfactory areas would be much greater. An area like the Lleyn peninsula, which is mainly covered with soils of a light sandy or gravelly texture, will probably have suffered even greater losses of lime owing to the greater freedom of drainage.

Recent data on the lime-status of Welsh soils.

At Bangor, advisory samples are dealt with from North Wales and also from Glamorganshire. Some impression of the present lime-status of soils in these two regions may be gathered from an analysis of the figures for the exchangeable lime content of the advisory samples examined during the year 1936. When samples taken from gardens, allotments, etc., are excluded, a total number of 113 samples of purely agricultural soils from the four North Wales counties of Anglesey, Caernarvonshire, Denbighshire and Flintshire, and 73 from Glamorganshire were analysed during the year. In the following Tables they are grouped according to their exchangeable lime content. The number in each group is expressed as a percentage of the total number.

TABLE III.

Distribution of Exchangeable Lime in Welsh Soils.

A.

Advisory samples from the four North Wales Counties, 1936.

Lb. Exchangeable CaO per acre.	*Percentage of Samples.*
0—1,000	Nil
1,000—2,000	8.9
2,000—3,000	15.0
3,000—4,000	16.8
4,000—5,000	16.8
5,000—6,000	9.8
6,000—7,000	7.9
>7,000	24.8

B.

Advisory Samples from Glamorganshire, 1936.

Lb. Exchangeable CaO per acre.	*Percentage of Samples.*
0—1,000	9.6
1,000—2,000	1.4
2,000—3,000	2.7
3,000—4,000	6.9
4,000—5,000	6.9
4,000—5,000	12.3
6,000—7,000	10.9
>7,000	49.3

The highest exchangeable lime category in the above Tables, viz., >7,000 lb. per acre, includes all soils containing free calcium

carbonate. The soils in this group have a high lime-status and are not likely to become deficient within, say, the next ten years. Glamorganshire shows about half its samples in this category because many of the soils, especially those from the Vale of Glamorgan, are derived from soft calcareous materials, and, therefore, contain much free carbonate. In North Wales many soils overlying Carboniferous Limestone are deficient in lime, whilst in certain parts of Denbighshire and Flintshire soils derived from calcareous drift materials still show the presence of free carbonate. What is somewhat surprising is to find, as in the Chirk area and the Tanat valley in Denbighshire, soils derived from non-calcareous materials containing quite large amounts of free calcium carbonate. This is evidence of very heavy liming in past times. About one-third of the >7,000 lb. per acre samples in Table IIIA come from these two areas.

The figures for the whole of the North Wales counties show about 60 per cent. of the samples to have an exchangeable lime content below 5,000 lb. per acre. As there are many more samples from the free carbonate areas relative to their size than from other districts, the actual area of lime deficient soils is certainly greater than 60 per cent. of the total. It would probably not be an over-estimate to state that two-thirds of the area of agricultural soils in North Wales is in immediate need of lime, especially when it is remembered that the upland soils and those of such districts as Lleyn are almost all deficient.

Table IIIB indicates that conditions in Glamorganshire are better, only about 30 per cent. showing immediate deficiency. This is mainly due to the natural calcium carbonate occurring in many of the soils. On the other hand, about 10 per cent. show extreme deficiency. These soils, mainly from Coal Measure Sandstones and Pennant Grits, require heavy dressings of lime or ground limestone to bring them up to a satisfactory level.

Lleyn Peninsula.—A portion of this area was surveyed during the summer of 1936, and analysis of twenty-five representative samples gave the following distribution for exchangeable lime content :—

TABLE IV.

Exchangeable Lime (CaO) of Soils from the Lleyn Peninsula.

Lb. exchangeable CaO per acre.	*Number of Samples.*
0—1,000	5
1,000—2,000	4
2,000—3,000	6
3,000—4,000	4
4,000—5,000	5
>5,000	1

These figures indicate a general deficiency of lime in this area. If 5,000 lb. per acre is taken as satisfactory, then 96 per cent. of the samples are deficient; 75 per cent. contain less than 4,000 lb., and 25 per cent. less than 1,000 lb. per acre. The latter require two tons or more of quicklime per acre to bring them up to standard. The upland soils of Wales are also, generally, in this lowest category. Many of them have never been limed, so that, through leaching, their available lime-status has reached a very low level. As the amount of exchangeable lime is now low, the losses will also be small. They have probably reached a point where the losses of calcium are about balanced by the calcium brought into solution by the process of weathering. Heavy liming is the only method of improving such soils.

Dressings needed to maintain satisfactory lime-status.

In view of what has been stated regarding the depletion of lime from soils, and the present low level of lime in many of them, it would appear that the Welsh farmer, whatever else he does, if he desires to raise the fertility of his soil to the optimum state, must first of all bring it to a satisfactory level of lime-status and then maintain it at or above this level. This can only be done by reviving liming as an ordinary farm practice. The amount to be added in the first instance will depend on that necessary to bring the soil to a satisfactory lime-status. It can then be maintained at about this level by light annual dressings or, more conveniently, by one heavy dressing during each rotation.

It has been found that the average annual loss, under conditions similar to those obtaining at the College Farm and in Anglesey, from soils at a satisfactory lime level is about 1½ cwt. As it is probable that, following a heavy dressing of lime, there is a temporary increase in the loss through leaching, and also, as when quicklime is applied, some of it becomes partially inactive through caking and carbonation, it is not possible to assume a 100 per cent. efficiency of the dressing. The writer would, therefore, recommend dressings at a higher rate, viz., 2 cwt. per acre per annum, in order to maintain the lime-status at a satisfactory level. Applied during a rotation, which under North Wales conditions covers seven or eight years, this would entail a dressing of 15 cwt. of lime, or 30 cwt. of ground limestone, per acre at some convenient time during the rotation.

Influence of fertilisers and manures on lime-status.

Nothing has been said regarding the influence of other manures on the conservation or depletion of soil exchangeable

lime. The investigations of Crowther and Basu (2) on the exchangeable bases of the Woburn plots show that farmyard manure tends to conserve lime-status, whilst sulphate of ammonia increases the loss of lime as compared with the no manure plot. A dressing of sulphate of ammonia is said to cause the removal of its own weight of $CaCO_3$. They believe that superphosphate has no appreciable effect on soil reaction or lime-status. Basic slag, on the other hand, helps to maintain the lime-status by supplying a certain amount of calcium, which becomes exchangeable. A ton of basic slag contains about 8 cwt. of combined CaO. A high percentage of this becomes available as exchangeable calcium. Therefore, heavy dressings of basic slag help to maintain the level of the lime-status. Nitro-chalk contains about half its weight of calcium carbonate, but no quantitative data are available on its effect on lime-status. On purely theoretical grounds, it would be expected to conserve rather than help to deplete the soil calcium. But, as the dressings applied are small, its effect would not be considerable. Thus, of the ordinary fertilizers introduced on the farm, basic slag will have the biggest effect in conserving the lime-status. A certain amount of lime is, also, returned to the soil in farmyard manure.

General Discussion and Conclusions.

Enough has been said to show that the danger to Welsh soils from lime depletion is serious, and is likely to become more so if the present neglect of liming is continued. In addition to the losses through drainage, the great increase in the number of lambs sold from Welsh farms constitutes a further drain on the soil lime. It seems to the writer that, however successful the present policy of marketing schemes and subsidies may be in temporarily improving the economic position of the farmer, no permanent advantage will be gained—in fact, the harm will be accentuated—unless the fertility of the soil is maintained and improved by keeping it well supplied with available lime. Not only will yields suffer, but a deterioration in quality and a general depression in the lime content of home-grown feeding stuffs is inevitable, if this is not already happening. All other methods of increasing yields, whilst perhaps temporarily successful, will eventually fail if the soil is allowed to remain deficient in lime. This deficiency is frequently indicated by failure of certain root crops and by poor take of clover and grass seeds. A revival of liming as a regular practice is essential for the future success of farming in Wales. The amount of lime necessary to maintain the soil at a satisfactory

level has already been indicated, *viz.*, 1-2 cwt. per acre per annum. It is, however, evident from the data presented in this paper that a high percentage of the soils require heavy initial dressings to bring them to the level which appears suitable, even under the conditions of acid farming practised in these districts. It has been suggested that the level should be 5,000 lb. per acre, or higher. For crops such as sugar beet, wheat, and possibly barley, the level should be raised still further to about 7,000 lb. per acre.

Table IIIA supplies data from which some estimate may be obtained of, at least, the order of magnitude of the lime dressings required to bring the agricultural soils of North Wales above the minimum satisfactory level of 5,000 lb. per acre. In 1935, the total acreage under crops and grass (1) in the four counties of Anglesey, Caernarvonshire, Denbighshire and Flintshire was 661,300. On the basis of the figures in Table IIIA, this area would require approximately 400,000 tons of lime, or about 800,000 tons of ground limestone to raise the lime-status above 5,000 lb. per acre. The annual loss of lime, from the same area, based on an average loss of 1 cwt. per acre, would be about 33,000 tons of quicklime. If a similar state of depletion be assumed for the whole of Wales (including Monmouthshire), the estimates for Wales would be roughly as follows :—

Lime needed to bring lime-status to satisfactory level—
1½ million tons.

Annual dressings required to maintain this level—
186,000 tons.

The above estimates are largely conjectural, but it is felt that they do indicate the order of magnitude of lime requirements. They do also emphatically suggest that the danger from lime depletion in Welsh soils is on the way to becoming a serious menace to their fertility. If Welsh agriculture is to prosper, one of the most urgent tasks is to restore, through liming, the lime-depleted soils to a satisfactory level.

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RECLAMATION OF UPLAND PEAT IN GLAMORGAN.

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The demonstration described in this article was not undertaken of set purpose, but incidentally, as a result of the failure of a group of thirty-two unemployed men to crop successfully two acres of upland peat 850 feet above sea level on the south-western slope of Mynydd y Gilfach, near Gilfach Goch. This land had been taken so as to minimise the possibility of disturbance that has been the lot of so many allotment associations in the industrial districts of Glamorgan.

The owner rented the two acres of land at £5 6s. 8d. a year and provided free of charge posts and wire to enclose it.

The land was occupied in the Spring of 1934 In the first place an improvement in the drainage was effected and a turf "wall" was erected. Thirty-two plots were laid out and the problem of cultivation was tackled in various ways. Some of the men who were allotted plots had gone from the land to the coal mines, while others were a generation removed from the land. All, however, had previously cultivated an allotment. A few trenched their plots, but most relied on deep digging. Light dressings of lime and/or poultry manure were also applied on several plots. Small seeds and potatoes were planted, but almost complete crop failure resulted. Much discouraged, the allotment holders were about to abandon their enterprise and to take over land lower down the valley, when the problem came to the knowledge of the County Agricultural Department.

A close inspection by members of the County Staff in July, 1934, prompted a renewed attack. The average annual rainfall of the demonstration area is about 80 inches. Further drainage seemed necessary, particularly the provision of a trap drain to prevent the surface water from the higher land flowing into the enclosed area. The beneficial effects of the trenching undertaken and of the application of lime and organic (poultry) manure were noted. The wiry nature of the turf which had been dug in was also noted and it was disclosed that very little lime and no fertilizers had been applied.

The rent was reduced from £5 6s. 8d. to £4 4s. 0d. and the rent for 1935 and 1936 was remitted. The Glamorgan County Agricultural Committee, in view of the large area (some 80,000

acres) of similar land in the county and the land hunger prevailing, decided to provide the necessary lime and fertilizers together with part of the cost of the small seeds and potato " seed " in 1935. The men agreed to undertake the reclamation work, the cultivation and the cropping as advised by the County Staff, who were much helped in their planning by the experience gained from the results of the pioneer efforts of the allotment holders in 1934.

The " mountain " peat varies in depth from one to two feet and rests on clay. The following table shows the (*a*) botanical analysis of the vegetation and (*b*) the chemical analysis of the top spit of peat, excluding the four inches of turf :—

(a) Analysis of Herbage.

	%
Flying Bent (*Molinia*)	55
Sheeps Fescue (*Festusa Ovina*)	20
Heath Matgrass (*Nardus Stricta*)	10
Heath Hairgrass (*Aira Flexuosa*)	8
Bentgrass (*Agrostis*)	7

(b) Analysis of Peat.

	%
Organic matter	30.00
Lime (CaO)	.303
Phosphoric Acid (P_2O_5)	.008
Potash (K_2O)	.015

The poor drainage, the tough turf and the poverty of the soil in lime and phosphates were the chief problems to be overcome in order to bring the soil into a state in which normal cultivation, liming and manuring would ensure average yields from suitable crops.

Reclamation Work.

(1) An open trap drain along the north and north-west boundary, open and stone lateral drains 15 inches to 18 inches deep alongside the paths, reduced the water table from near the surface to the depth of the drains.

(2) The turf was pared and burnt and the ashes spread over the plots immediately after cooling. These ashes contained 2 per cent. of phosphoric acid. Extensive burning of the soil had to be guarded against.

(3) Digging, trenching and breaking up of the " soil " followed the paring and burning of the turf.

(4) Burnt lump lime was applied in the autumn of 1934 at the rate of about 3 tons per acre. The lime was distributed in small heaps, covered with soil, spread when slaked, and immediately forked in.

(5) Fertilizers were applied later at the following rates per acre :—

Slag (16 per cent. P_2O_5)	1 ton.
Sulphate of Potash (48½ per cent.)	4 cwt.
Nitro-Chalk (15 per cent. N.)	2 cwt.

The beneficial effects of the drainage, deep cultivation, weathering, and especially of the lime were very noticeable at planting time. The texture of the original soil was radically changed and a good tilth had been secured.

Cropping in 1935.

Crops usually grown on allotments in the district were selected and the yields are given below.

Crop.	*Area.* Perches.	*Quantity.* T C Q	*Value.* £ s. d.
Potatoes	213	14 0 0	84 0 0
Cabbages ...	32	2 0 4	19 4 0
Roots ...	27	1 4 0	7 4 0
Peas and Beans	11	10 0	6 4 0
Totals ...	283		116 12 0

The remaining 87 perches are occupied by paths and drains.

Arran Banner and Arran Victory were grown, as these varieties of potatoes had been proved to be good croppers in the county. The root crops included beetroot, carrots, parsnips, turnips and swedes. The value of the crops taken may be placed at £60 per acre.

Costs (per acre).

Operations.			*Lime and other Fertilizers.*		
	Total.	*First Year.* (Prop.)	*Quantity.*	*Cost.*	*First Year.* (Prop.)
	£	£ s.	T C	£ s.	£ s.
Draining	6	12 ($\frac{1}{10}$)	Lime 3 12	3 12	18 ($\frac{1}{4}$)
Paring and Burning	6	1 10 ($\frac{1}{4}$)	Slag 1 $2\frac{1}{2}$	3 14	1 5 ($\frac{1}{3}$)
Trenching	12	3 0 ($\frac{1}{4}$)	Sulphate of Potash $4\frac{1}{2}$	2 12	1 6 ($\frac{1}{2}$)
			Nitro Chalk $2\frac{1}{4}$	18	18
	24	5 2		10 16	4 7

The charges per acre against the first year's crops were :—

	£ s. d.
Operations	5 2 0
Lime and other Fertilizers	4 7 0
Cultivations	5 0 0
Seed Potatoes (12 cwt.)	3 6 0
Small seeds	0 15 0
Total	£18 10 0

About an acre was planted with winter brassicae in the autumn.

An analysis of a sample of the soil taken in the early spring of 1935 and in 1936 affords an interesting comparison.

	1935	*1936*
	%	%
Lime (CaO)	.080	.513
Phosphoric Acid (P_2O_5)	.008	.028
Potash (K_2O)	.015	.014

The slow decay of the peat was noticeable.

On one of the plots a load (about 15 cwt.) of colliery stable manure was dug in and increased yields resulted. The shortage of animal manure raises the question of green manuring as a supplementary source of organic matter.

The immunity of all the crops to frost in May, 1935, was a remarkable feature. In the valleys the potato crops suffered severely—here they were untouched.

Cropping in 1936.

Yields were good. Stump-rooted carrots, beetroot and medium-rooted parsnips grew very well but, as in 1935, potatoes were a marked success. The quality of the tubers was striking.

Only a normal dressing of fertilizers—1 cwt. of nitro chalk, 8 cwt. of basic slag, and 2 cwt. of sulphate of potash—was applied.

The gradual admixture of the peaty soil with some of the underlying clay will begin in 1937.

The success of this spade labour reclamation scheme, the presence of large areas of similar land (the gradients are steeper in some districts in the county) and the seemingly special suitability of the land for potato growing, indicate the necessity for a large scale demonstration with suitable mechanical equipment. Some 400 to 500 tons of "seed" potatoes are distributed annually at low cost to assist allotment holders in Glamorgan and the possibility of securing this "seed" from upland peaty land is well worth investigation.

The cost of reclamation was heavy but the crop yields exceeded expectation.

The reclamation of similar land for allotments is definitely demonstrated to be a practical undertaking.

We wish to acknowledge the assistance of our colleagues on the staff of the County Agricultural Department, the Advisory Chemist of the University College of North Wales, Bangor, and the allotment holders.

THE FINANCIAL IMPORTANCE OF DEATHS AND DEPRECIATION IN POULTRY FLOCKS.

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It has been estimated by the National Veterinary Medical Association that the annual loss to the poultry industry of this country as a consequence of diseases is in the region of four million pounds. In the United States of America the annual loss is placed at the equivalent of eleven million pounds. These statements seem excessive, but a special study of the losses by deaths and depreciation amongst Welsh flocks indicates that the estimate for this country is approximately correct.

The losses are not confined to deaths amongst laying flocks but wastage is also found at all stages from the incubator to the laying pens. In the incubator we have considerable wastage as a consequence of infertility or because of dead germs and chicks dead in the shells. Of the chicks which are hatched some have to be destroyed owing to physical defects while unless special care is taken during the brooder stage, that is the first six weeks of a chick's life, further losses are likely to be considerable. Once the chicks have passed this initial stage, the danger of exceptionally high mortality rates is appreciably less, but there are cases of whole broods having succumbed to diseases after leaving the brooder. Lastly there are the losses which occur by deaths amongst birds in laying flocks and by normal and abnormal depreciation of birds which are culled and sold from those flocks. In Wales the losses by deaths and depreciation of birds in some laying flocks during the two years 1934-35 and 1935-36 amounted to about 32 pence per average bird or 2.8 pence per dozen eggs produced.

Losses in the Incubator and Brooder.

Detailed information is available relating to the hatching of 10,878 vigorous chicks on Welsh farms during the 1936 hatching season. Unfortunately it was not possible to keep a record of these chicks up to the time they were sold or transferred to laying flocks but from such information as is available it appears that some 50 birds or say 25 pullets are reared for every 100 eggs

placed in the incubator. The following is a summary of the results :—

Hatching Results, 1935-36.

	Number.	*Per cent.*
Eggs placed in Incubators ..	17,786	—
Infertiles removed ...	3,315	18.64
Fertile Eggs	14,471	81.36
Dead germs	1,372	7.71
Dead in shells and Weak Chicks ...	2,721	15.30
Vigorous chicks removed to brooders	10,378	58.35

The available records relate to 17,786 eggs which were placed in the incubators. Of this number 3,315 or 18.64 per cent. were found to be infertile. On the assumption that the cost of production amounted to one shilling per dozen eggs this initial loss would amount to nearly 1s. 7d. per 50 birds reared to maturity. The number of dead germs formed 7.71 per cent. of the original number of eggs used or a further cost for eggs alone of 7.71 pence per 50 chicks produced. Dead chicks in shell and weak chicks which had to be destroyed accounted for 15.3 per cent. of the original number. The number of vigorous chicks placed in the brooders amounted to only 58.35 per cent. of the original number and to 71.72 per cent. of the total fertile eggs used. The total direct loss on the basis of cost of eggs and hatching would not be less than 5s. 3d. for each 50 chicks reared. This rate of direct loss may be raised by any difference which may be allowed between the assumed cost of production of hatching eggs and purchase prices.

Similar records collected by investigators in England show that with few exceptions poor hatching and rearing results are being obtained by all rearers. It is the general opinion of farmers in Wales that the hatching results are growing steadily worse. All the results show that the loss of 40 out of every 100 eggs placed in the incubators was due to defects associated with the breeding flocks or to unfavourable conditions in the incubators and their management.

Data relating to 7,645 chicks placed in brooders during 1935-1936 show that during the first six weeks 11.3 per cent. died or had to be destroyed. The records show that the mortality-rates for chicks hatched out during the four months November to February ranged from 14 to 25 per cent. of the numbers transferred to brooders while the smallest losses occurred amongst chicks transferred to the brooders during the month of October. Taking

all broods over all the seasons nearly half the losses occurred in the first two weeks.

Losses during the Brooder Stage.

	Number.	*Per cent.*
Chicks transferred to brooders ..	7,645	100.0
Deaths 1st week	260	3.4
2nd week	155	2.0
3rd week	93	1.2
4th week	81	1.1
5th week	72	1.0
6th week	202	2.6
Total	863	11.3

During the last week the chicks were carefully examined and all weak and backward ones were destroyed and as a consequence the losses in that week amounted to 2.6 per cent. of the original number.

There is no available information showing the importance of deaths between the time the birds leave the brooder and when they reach maturity but the indications are that they are not likely to be less than 5 per cent. On the basis of the foregoing statements the losses may be summarised as follows :—

Source of Loss.	*Rate of Loss.* %	*Rate of Loss per 100 Eggs used.* %
Incubator	41.6	41.6
Brooder (incubator—ex-brooder) ..	11.3	6.6
Rearing (brooder to laying-pens or sales)	5.0	2.6
Total Loss		50.8

The total estimated losses during these stages amounted to 51 eggs and chicks for every 100 eggs placed in the incubators. It is not possible to determine the total financial loss incurred but it may be stated that in addition to the wastage of eggs and of incubator capacity there is wastage of fuel, of food, of labour and of brooder and housing capacity. On the actual birds finally passed for sale or for transfer to laying pens, the loss of eggs in incubators, and of chicks in brooders soon after the brooder stage, adds a cost of at least 6d. per bird and in many cases of much more than this sum.

Deaths amongst Laying Flocks.

The most reliable records of deaths amongst laying flocks are those collected at the various Egg Laying Trials. These records show that from 1927-8 to 1934-5 the mortality rose from about 5 per cent. to 16 per cent. The importance of deaths amongst the different breeds shows some variation, the higher rates occurring amongst White Wyandottes and White Leghorns.

Mortality rates amongst commercial laying flocks are not strictly comparable with those for birds sent to Trials. In the latter case the birds are selected and are still in their pullet year and remain at the Trial centre for 48 weeks unless death occurs. With commercial flocks there may be frequent additions during the year while culling and selling from the flocks occurs at all times. In general, however, the normal period of exposure to risk of death will not be less than eighteen months and for the hens which survive may often be as long as two years. Because of the higher average age of birds in commercial flocks higher annual death-rates might be anticipated. The records for some Welsh flocks show that in 1934-5 the death-rate was as high as 17.7 per cent. of the yearly average number of birds, while in the following year it had increased to 19.0 per cent. The following summary shows that in both years nearly half of the flocks for which the information was available had death-rates exceeding 15 per cent.

Number of Cases.

Death-Rates on Average Numbers.	*1934-5.*	*1935-6.*
Over 15 per cent.	9	14
Under 15 per cent.	10	19
Total	19	33

In 1934-5 there were three cases and in the following year eight cases where the death-rate exceeded 30 per cent. while the number of cases with rates of less than 10 per cent. were five and nine respectively. It is important to bear in mind that all flocks are subject to the risks of the higher death-rates.

Normal and Abnormal Deterioration.

In addition to the losses by deaths there is considerable financial loss due to deterioration of birds which remain in the laying flocks until they are sold. Since 1920 there has been considerable reduction in the normal periods during which birds remain in laying flocks and therefore the cost of deterioration—

the difference between the cost of producing a pullet and the price which it will later realise as a boiler—must be spread over a shorter period. If this change has also had the effect of reducing the total number of eggs produced during their productive life the cost of depreciation must also be spread over a smaller total number of eggs.

There exists no clear evidence of what may be considered normal and what must be considered as abnormal deterioration. Culling and selling of older birds is more often prompted by the relative physical productivity of pullets to old hens, and the cost of producing pullets and the economic productivity of birds during their second and third laying seasons are usually ignored. Thus a comparison between the selling rate for flocks before the War and those for flocks at the present time cannot be taken as a measure of increasing physical deterioration. It may be stated, however, that any increase in the number of birds which it has been found necessary to cull from laying flocks within the period of productive life intended for them may be taken as a measure of decreasing physical fitness of birds reared for egg production. Further, any increase in culling-rates made necessary by failure of health may be taken as a measure of increasing abnormal deterioration. Normal depreciation would then refer to losses by sales prompted by purely economic considerations and would change with changing economic circumstances. It is almost certain that much of the increase in selling-rates is a measure of increased efficiency in management.

Losses by Deaths and Depreciation.

Owing to the absence of separate information for the cost of producing pullets they have been given an estimated average value for the two years of 5s. 3d. each at the time of being transferred to the laying pens. All birds culled and sold from laying flocks during the two years realised an average price of 2s. 1d. each. There was therefore a depreciation charge of 3s. 2d. which had to be spread over a productive life of 18 months to two years, or over 200 to 275 eggs. For individual years it is not possible to distinguish deaths and depreciation of pullets from those of other birds and the cost of these items has been determined from the average value of the total intake. In the case of fourteen flocks for which information is available in each of the two years the loss on birds sold amounted to 2s. 5d. per bird in 1934-5 and 2s. 8d. in 1935-6. In addition there was a further loss from writing down the value of the birds remaining in the laying flocks at the end of each year. This amounted to

11d. per bird remaining in the flocks at the end of 1934-5 and to 1s. 0d. for those in the flocks at the end of 1935-6.

The average total loss per farm for the fifty-two cases examined over the two years amounted to £28 19s. 6d. and this ranks next to labour in its importance as a cost of production item. This total estimated charge had to be borne by an average laying flock of 217 birds. Deaths accounted for 30.2 per cent., loss on birds sold for 42.5 per cent. and write-down in values of birds still in the laying flocks for 27.3 per cent. of the total. The average results for fourteen flocks in each of the two years were as follows :—

Financial Loss by Deaths, Sales and Write-down. (14 Flocks).

Source of Loss.	*1934-5.*		*1935-6*	
	£ s. d.	%	£ s. d.	%
Deaths ..	9 4 9	33.06	9 19 0	35.47
Sales	10 15 8	38.61	11 10 9	41.12
Write-down	7 18 3	28.33	6 11 4	23.41
Total ..	27 18 8	100.00	28 1 1	100.00

In the first year the average size of the laying flocks was 210 birds as compared with 190 birds in the second year. Death- and selling-rates for the fourteen flocks in each of the two years were :—

Per cent. of Average Number of Layers.

	1934-5.	*1935-6.*
	%	%
Deaths .	21.3	25.5
Sales ..	41.8	51.3

As a consequence of the higher death- and selling-rates in the second year there was an increase in the total financial loss in that year, and in 1934-5 the average financial loss by deaths and sales amounted to £20 0s. 5d. per farm as compared with £21 9s. 9d. in the following year. There was, however, a reduction in the latter year of nearly £1 7s. 0d. in the financial loss by depreciating the values of the birds remaining in the flocks at the end of the accounting period.

The records show that the total loss by deaths and depreciation ranges from 2s. 6d. to 3s. 0d. per bird on the yearly average number in the flocks of which losses on birds sold from the laying

flocks was the largest item. The following summary shows the total losses per bird and per dozen eggs produced :—

Losses by Deaths and Depreciation.

	All Flocks for both years.	*14 Flocks in each of the two years.*	
		1934-5.	*1935-6.*
	Loss per Bird.		
	d.	d.	d.
Deaths	9.68	10.56	12.55
Sales	13.61	12.32	14.54
Write-down	8.75	9.04	8.28
Total	32.04	31.92	35.37
	Loss per dozen eggs.		
Deaths	0.85	0.99	1.16
Sales	1.19	1.15	1.34
Write-down	0.76	0.85	0.76
Total	2.80	2.98	3.26

In each group the total loss amounts to nearly three pence per dozen eggs and it should be possible to effect some reduction especially in the loss by deaths.

In all cases where the death-rate was less than 10 per cent. of the total intake (total of original flock and pullets added) the average cost of deaths and depreciation for the two years amounted to 2s. 4d. per bird in the laying flock as compared with 3s. 1d. for those with a rate of more than 10 per cent. The detailed statements were :—

	High Death-Rate.	*Low Death-Rate.*
Death-Rate per cent. of Total Intake	19.5	5.9
Per cent. of Average No.	29.6	9.4
Source of loss per Bird.	*Pence.*	*Pence.*
Deaths	15.50	4.90
Sales	12.52	14.51
Write-down	8.69	8.77
Total	36.71	28.18

There was a difference of 10.5d. in the losses per bird by deaths in favour of the group with the low death-rate, but part of this was discounted by the differences in the losses by sales. As a consequence of the lower average egg yield obtained from the

flocks with high death-rates they had total losses amounting to 3.86d. per dozen eggs, these being nearly 1d. per dozen eggs higher than for the other group. The variations in these losses were due entirely to the differences in the importance of deaths and sales, the average values at the beginning and end of the accounting periods as well as the average realised values for birds sold being approximately the same for both groups.

Deaths, Depreciation and Egg Yields.

Having measured the losses due to deaths and depreciation in groups arranged by death-rates it is also possible to show these losses for groups arranged by egg yields.

It is the general opinion that breeding and feeding for high production has been largely responsible for the increased death-rate and the need for more frequent culling of laying flocks. The post-mortem examination of birds which have died at egg-laying trials shows that about one-third of the deaths were associated with diseases of the reproductive system. These birds are placed in the laying pens in October and about one-third of the deaths are likely to occur during the first twenty-four weeks of the test, while about one-half of the total deaths usually occur during the sixteen weeks from May to August. The results indicate that large numbers of the birds are unable to withstand the strain of high production during the spring and early summer months.

The records for commercial flocks in Wales do not show any positive association between high egg yields and high death-rates. In each of the two years for which the information is available the records show that where high death-rates occur egg yields were below the average. The results were :—

	High Yields.	*Low Yields.*
No. of Cases	26	26
Average Yields.		
1934-35	152	115
1935-36	160	121
Both years	158	118
Death-Rates.		
1934-35	10.2	23.2
1935-36	16.3	22.0
Both years	14.4	22.5
Selling-Rates.		
1934-35	48.3	48.1
1935-36	55.1	46.3
Both years	53.0	47.0

Over the two years there was a difference in the average yields of the two groups of forty eggs, while the difference in the number of deaths was about eight per 100 birds in the laying flocks. In 1935-6 the group with higher egg yields showed a substantially heavier death-rate than a similar group in the former year.

In the apparent disagreement of the evidence from commercial flocks and that from laying trials there is a difference of conditions but no necessary conflict. It appears that breeding birds for high yields has increased the risk of death directly due to high production, and has also increased the risk of death because of the increased susceptibility to diseases. In the course of breeding for high yields, and possibly in the continued repetition of artificial processes of rearing, conditions are induced which lead to low vitality in flocks, and consequently to low yields under conditions of commercial maintenance, even before very high death-rates occur. But when the very high rates are realised in the commercial flocks, as is recorded above, they are accompanied by low yields probably partly because of low average vitality under the conditions of maintenance, but also because some birds are still kept in the flocks when they are in a declining condition.

However, the statistical position in a commercial flock is quite different from that of the laying trials, where the original number is fixed and no change occurs except by death or accident. In commercial flocks some deaths may be avoided by culling and sales in one case, but suffered through ignorance or neglect in another. One manager may set out to give his birds " a short life but a busy one " and sell before the full effects on the constitutions of the birds are realised. Another may set out to keep his birds for two years or at least eighteen months from transfer to the laying flock, and then suffer by epidemic or other forms of disease. But all possible conditions and risks of death-rates are affected by rates of culling and selling.

The importance of sales from the laying flocks was about the same for both groups arranged by egg yields, but the final values recorded for flocks showing higher yields were depreciated at a higher rate than those for flocks giving low production, and as a consequence the importance of the total loss per average bird in the laying flocks was approximately the same. When the groups are compared on the basis of losses per dozen eggs

the advantages are seen to be definitely in favour of the high yielding flocks. The individual losses were :—

Losses per Dozen Eggs.

	High Yield. d.	*Low Yield.* d.
Deaths	0.56	1.22
Sales	1.03	1.39
Write-down	0.80	0.72
Total	2.39	3.33

The low yielding flocks had a loss per dozen eggs, for deaths, of more than twice the amount shown by the high yielding flocks, while the loss from sales was 0.36d. per dozen eggs higher. A general improvement in health and physique resulting in a substantial improvement in egg yields would have the effect of substantially reducing the losses per dozen eggs due to deaths.

On the basis of average annual yields and an assumed annual average price of 1s. 3d. per dozen eggs the high yielding flocks would have to produce about twenty-five eggs and the low yielding flocks about twenty-six eggs per bird to cover the losses by deaths and depreciation. But these figures do not justly show the more favourable position of the high yielding flocks. The annual production for the high yielding flocks was 43 per cent. of the possible production, while that for the other group was only 32 per cent. Thus, while the former group produced sufficient eggs (at 1s. 3d. per dozen) to cover this total loss in about fifty-eight days, the other group required eighty-one days in which to produce the necessary eggs.

Death-Rates, Selling-Rates and Replacement-Rates.

The total loss by deaths and sales during the two years amounted to 68.4 per cent. of the yearly average number of birds in the laying flocks and the replacement rate to 69.1 per cent. Annual replacement rates are determined by three main considerations, namely :—

(*a*) Future intentions regarding the size of laying flocks;
(*b*) The need of making good losses through deaths;
(*c*) Individual policies relating to the culling and selling of birds from laying flocks.

Low replacement-rates and low selling-rates may be accompanied by high death-rates, especially where hatching has been

unsuccessful and insufficient pullets are available for replenishments. When a poor hatching and rearing season is experienced the size of the laying flock may be maintained either by the purchase of additional pullets or by a reduction in the normal rate of culling and selling. If sales of old birds are limited there will be an increase in the average age of the birds in the laying flock, and with the higher age-level, higher death-rates may occur.

In all the cases where the death-rate was less than 10 per cent. of the total intake (total of original flock and pullets added) the total loss by deaths and sales amounted to 68.5 per cent. and the number of pullets added amounted to 68.4 per cent. of the yearly average number of birds in the laying flock, but where the deaths exceeded 10 per cent. of the total intake the loss was 74.5 per cent. and the replenishments 78.7 per cent., thus resulting in a small reduction in the size of the laying flocks.

In the following summary the flocks have been grouped according to the selling-rates and this shows that the replacement-rate was highest for flocks with the high selling-rate.

Average Selling Rate.	*High Selling-Rate.*	*Low Selling-Rate.*
	(Per cent. of Average Numbers).	
1934-5	70.6	25.6
1935-6	62.9	31.0
Both years	65.4	28.8
Death-Rate.		
1934-5	11.9	23.5
1935-6	19.4	18.5
Both years	17.0	20.7
Replacement-Rate.		
1934-5	71.1	45.6
1935-6	86.7	57.8
Both years	81.5	53.1

It will be seen that in 1934-5 the replacement-rate for each group was approximately the same as the loss by deaths and sales, but in the following year the additions to the laying flocks were in excess of the increased losses. During 1935-6 there was a decline in the importance of sales and an increase in the death-rate for the group with the higher selling-rate, while the other group showed an increase in the selling-rate and a decline in the death-rate. The general health of flocks with the high death-rates in 1934-5 was so seriously affected that it became necessary to dispose of large numbers of birds in the following year, but even

so heavy losses by deaths still occurred and this largely accounts for the close association between high death- and selling-rates in 1935-6.

The average cost per bird by deaths and depreciation for the two years was lowest for the group with the lower selling-rate. Detailed statements for each group were as follows :—

Losses by Deaths and Depreciation.

	High Selling-Rate.		*Low Selling-Rate.*	
	Per Bird.	*Per Dozen.*	*Per Bird.*	*Per Dozen.*
	d.	d.	d.	d.
Deaths	8.52	0.73	11.40	1.02
Sales	16.05	1.38	9.33	0.84
Write-down	9.06	0.78	9.14	0.82
Total	33.63	2.89	29.87	2.68

The smaller losses by deaths recorded for those flocks with the higher selling-rates were more than offset by the higher losses by sales. Lower initial and final values were recorded for those flocks having the higher selling-rate, but the sales of younger birds from the laying flocks realised the higher prices.

Conclusions.

This study shows that the annual losses as a result of low effective fertility rates, increasing death-rates and the increasing culling and selling of birds from laying flocks are a heavy financial burden and any elimination of their causes will have an appreciable influence upon the profitableness of enterprises.

The general results of the 1936 hatching season were bad and indicate the need for special care when selecting birds for breeding purposes. In many cases the birds are carefully selected and mated in pens of twelve hens to one cockerel, but there is evidence of less careful selection and mating resulting in abnormally low fertility rates.

The use of incubators is almost universal and there is need of some special study of the results obtained from different types of machine. It is very important that these machines should be given proper attention at the beginning and during the hatching season in order to ensure that each part is functioning efficiently.

Chicks hatched out by incubators require special care and attention during the brooder stage. No comprehensive data is available indicating the number of deaths which occur during this

stage, but the indications are that they are exceptionally heavy on many general farms. There is need for some special study of types of brooders used and the general management of chicks during the early stages of their life.

Information relating to deaths amongst laying flocks is more comprehensive and reliable. It shows that these have steadily increased in importance and are seriously affecting the profitableness of the industry. In particular cases disease had so affected the flocks that it was necessary to dispose of all the birds and buy in a new stock. The specialist poultry flocks are more vulnerable, since they are often concentrated on a smaller area of land. In such cases an outbreak of disease spreads rapidly and difficulty is experienced in finding fresh clean land for birds not affected. Under these circumstances managers are often forced to reduce their laying flocks to a minimum for a number of years in order that some of the land may have a rest, and during these years the charges for capital depreciation are a heavy burden upon the reduced laying flocks.

In general the financial loss by sales of old birds and culled pullets was the most important though less than that by deaths for those cases with the high mortality-rates. The records show that where the stock has become affected by disease the financial loss either as a consequence of high death- or selling-rates, or low egg yields adds considerably to the cost of egg production. But even with normally healthy stock the annual disposals result in losses that are of sufficient importance to warrant some special study of this problem in order to determine the extent to which sales are prompted by purely economic considerations and the extent to which such sales are necessary owing to physically defective stock.

REPORT OF EXPERIMENTS ON THE FEEDING OF POULTRY WITH HIGH, MEDIUM, AND LOW PROTEIN RATIONS.

By J. O. Thomas, M.Sc., N.D.A., N.D.D.,

Dauntsey's School, West Lavington, near Devizes.

EXPERIMENT I.

The Effect of the Addition of Protein to the Ration of Laying Hens.

Forty-five Rhode Island Red hens, hatched from the same flock on February 18, 1934, were used for this experiment. The

birds were divided into three equal lots, and fed on high protein, medium protein, and low protein rations respectively. Similar houses and grass runs were used for each lot of birds.

Method of Feeding.

Dry mash, oyster shell, and water were available to the birds at all times, and grain was provided every evening.

The number of eggs and total weight of eggs from each section were recorded daily, and the body weight of birds noted at the commencement and end of the experiment. The food consumption and the financial difference as a result of different feeding were calculated at the end of each month.

Formulae of Mashes.

	High Protein Section. *lb.*	*Medium Protein Section.* *lb.*	*Low Protein Section.* *lb.*
Bran	19½	20¾	22
Middlings	39	41¾	44
Maize Meal	19½	20¼	22½
Sussex Ground Oats	9¾	10¼	11
Fish Meal	4	2	—
Meat Meal	4	2	—
Soya Bean Meal	4	2	—
Salt	¼	½	½
	100	100	100

Financial Results—January 29, 1935—May 28, 1936.
High Protein Section.

Total weight of birds (15) at commencement —95 lb. = 6.33 lb. per bird.
Total weight of birds (14) at May 28, 1936—84 lb. = 6.00 lb. per bird.

	Mash. *Wt.* *lb.*	*Mash.* *Price.* *s. d.*	*Corn.* *Wt.* *lb.*	*Corn.* *Price* *s. d.*	*No. of eggs.*	*Av. Wt. Eggs.* *oz.*	*Cost of food per doz eggs.*
Jan.-Feb.	100	9 3½	56¼	1 7	239	2.28	6.48d.
Feb-Mar.	65¾	5 7½	56¼	1 7	280	2.04	3.60d.
Mar.-Apr.	36¼	3 4½	56¼	1 7	239	2.11	2.88d.
Apr.-May	36	3 3½	56¼	1 7	230	2.0	2.54d.
May-June	40	3 8	56¼	1 7	201	2.0	3.76d.
June-July	45	4 2	56¼	1 7	176	2.0	4.70d.
July-Aug.	40	3 8	56¼	1 7	135	2.0	5.60d.
Aug.-Sept.	42	3 10½	56¼	1 7	129	2.0	6.09d.
Sept.-Oct.	36	3 3¾	56¼	1 7	106	2.1	6.64d.
Oct.-Nov.	35	3 2¾	56¼	1 7	30	2.0	23.10d.
Nov.-Dec.	54	5 0	56¼	1 7	36	2.2	26.34d.
Dec.-Jan.	50	4 7½	56¼	1 7	68	2.0	13.15d.
Jan.-Feb.	62	5 8¾	56¼	1 7	139	2.1	7.57d.
Feb. Mar.	75	6 11¼	56¼	1 7	235	2.2	5.29d.
Mar.-Apr.	80	7 4½	56¼	1 7	224	2.1	5.74d.
Apr.-May	78	7 2½	56¼	1 7	173	2.1	7.31d
						Average.	Average.
Total	875	£4 0 5	899.85	£1 5 4	2640	2.1	...

Cost of producing one dozen eggs over whole period = 5.7d.
One hen died. Post mortem reports Visceral Gout.

Medium Protein Section.

Total weight of birds (15) at commencement—89 lb. = 5.93 lb. per bird.
Total weight of birds (15) at May 28, 1936—92 lb. = 6.15 lb. per bird.

	Mash. *Wt.* *lb.*	*Price.* *s.*	*d.*	*Corn.* *Wt.* *lb.*	*Price.* *s.*	*d.*	*No. of eggs.*	*Av. Wt. Eggs. oz.*	*Cost of food per doz eggs.*
Jan.-Feb.	100	8	11½	56¼	1	7	226	2.31	6.60d.
Feb.-Mar.	89½	8	0½	56¼	1	7	305	2.26	4.44d.
Mar.-Apr.	53½	4	10	56¼	1	7	328	2.16	2.88d.
Apr.-May	50	4	6	56¼	1	7	280	2.1	3.12d.
May-June	45	4	0¼	56¼	1	7	206	2.0	3.93d.
June-July	48	4	3¾	56¼	1	7	160	2.1	5.30d.
July-Aug.	46	4	1¼	56¼	1	7	151	2.0	5.44d.
Aug.-Sept.	49	4	5	56¼	1	7	86	2.0	10.08d.
Sept.-Oct.	40	3	7½	56¼	1	7	59	1.8	12.64d.
Oct.-Nov.	44	3	11½	56¼	1	7	32	2.3	24.93d.
Nov.-Dec.	36	3	2¾	56¼	1	7	48	2.0	14.48d.
Dec.-Jan.	40	3	7¼	56¼	1	7	79	2.1	9.45d.
Jan.-Feb.	55	4	11½	56¼	1	7	116	2.2	8.12d.
Feb.-Mar.	60	5	4¼	56¼	1	7	167	1.9	6.01d.
Mar.-Apr.	62	5	7	56¼	1	7	93	2.1	11.09d.
Apr.-May	60	5	4¾	56¼	1	7	82	2.1	12.25d.
Total	878	£3 18	11½	899.85	£1 5	4	2213	2.2	

Cost of producing one dozen eggs over whole period = 5.1d.

Low Protein Section.

	Mash. *Wt.* *lb.*	*Price.* *s.*	*d.*	*Corn.* *Wt.* *lb.*	*Price.* *s.*	*d.*	*No. of eggs.*	*Av. Wt. Eggs. oz.*	*Cost of food per doz eggs.*
Jan.-Feb.	100	8	7½	56¼	1	7	172	2.32	8.52d.
Feb.-Mar.	50	4	3¾	56¼	1	7	231	2.12	3.67d.
Mar.-Apr.	30	2	7	56¼	1	7	250	2.07	2.40d.
Apr.-May	25	2	1¾	56¼	1	7	242	2.0	2.21d.
May-June	22	1	10½	56¼	1	7	198	2.1	2.51d.
June-July	26	2	2¼	56¼	1	7	145	2.0	3.78d.
July-Aug.	30	2	6¾	56¼	1	7	64	1.9	9.32d.
Aug.-Sept.	35	3	0	56¼	1	7	29	2.0	22.34d.
Sept.-Oct.	40	3	5¼	56¼	1	7	32	1.9	22.50d.
Oct.-Nov.	56	4	9¾	56¼	1	7	33	2.5	27.91d.
Nov.-Dec.	60	5	1¾	56¼	1	7	61	2.2	15.88d.
Dec.-Jan.	62	5	3¾	56¼	1	7	85	2.1	11.68d.
Jan.-Feb.	64	5	6	56¼	1	7	74	2.1	12.16d.
Feb.-Mar.	70	6	0	56¼	1	7	97	2.2	11.25d.
Mar.-Apr.	75	6	5¼	56¼	1	7	136	1.9	8.49d.
Apr.-May	71	6	1¼	56¼	1	7	105	2.1	10.54d.
Total	816	£3 10	1	899.35	£1 5	4	1954	2.1	

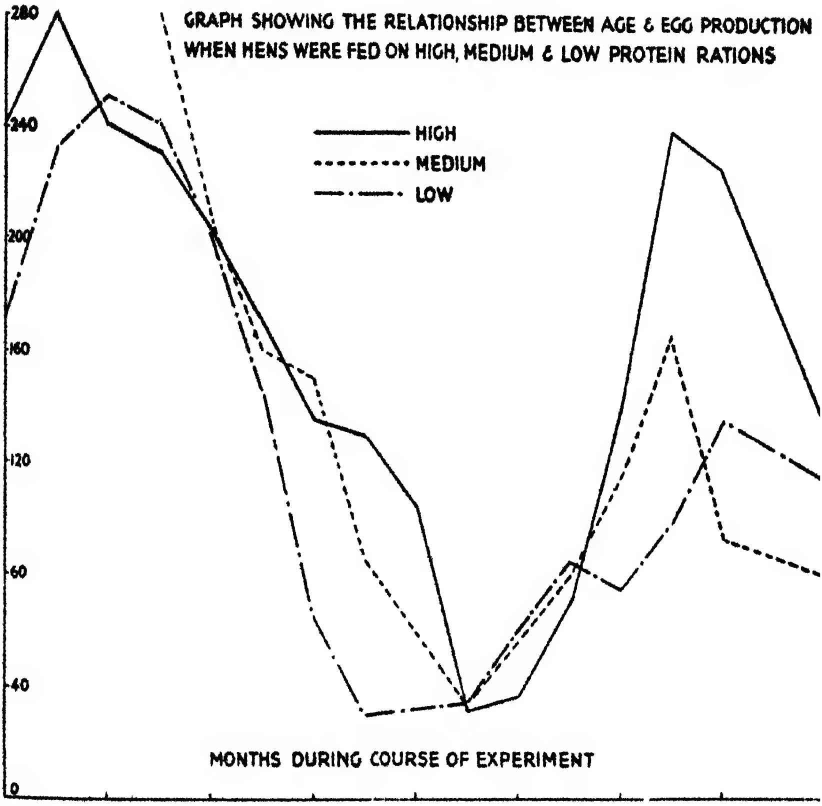
Cost of producing one dozen eggs over whole period = 7d.

Conclusions.

The cost of egg production varied considerably throughout the year in all three sections. As shown above, the comparative cost of producing one dozen eggs from each section over the whole period was: High protein, 5.7d.; medium protein, 5.1d.; low protein, 7d.

To a poultry farmer with 1,000 laying birds with an average annual egg production of 200 per bird, a profit of approximately

£85 and £140 would result when using a medium protein ration over a low and high protein ration respectively. These figures also indicate that it is uneconomical to feed a high protein ration to matured birds. The graph below indicates a definite correlation between age of bird and egg production in all three sections.



Moulting in the low protein pen took place approximately two months before the birds in the high and medium protein sections, with a corresponding decrease in egg production. The recovery from the moult was found to be far more rapid in the high protein section. After the birds had reached the age of two years there was a gradual decrease in egg production.

The Effect upon the Herbage.

The botanical composition of the original sward.

	%
Wild white clover	35
Grass (perennial rye-grass dominant species) ..	45
Dandelions	15
Thistles and other weeds	5

The botanical composition after three months' treatment (February, March and April).

	High Protein Section.	*Medium Protein Section.*	*Low Protein Section.*
	%	%	%
Grass ..	40	55	95
Clover	35	5	2
Dandelions	20	30	1
Thistles and weeds	5	10	2

The productivity of the herbage in the high protein section was approximately twenty times greater than that of the low protein section.

From these figures and observations, it is interesting to note that the birds supplemented the protein deficiency in their rations by consuming the clover and dandelion content of the herbage. Thus, folding poultry with low protein rations may yet be another simple method of improving poor grassland.

EXPERIMENT II.

The Effect of Feeding High Protein and Low Protein Rations to Young Chicks.

Seventy-four Rhode Island Red chicks were hatched from the same batch of eggs on February 19, 1935. The chicks were divided into two equal lots, and placed in two similar brooders. Feeding commenced on February 21, one brooder receiving a high protein ration and the other a low protein ration.

Composition of Rations.

	High Protein	*Low Protein.*
	lb.	*lb.*
Maize Meal	35	35
Middlings	35	35
Bran	16	16
Sussex Ground Oats	10	10
Cod Liver Oil	1¼	1¼
Fish Meal	7	—
Dried Milk	5	—
Limestone Flour	2	2
Salt ..	¾	¾
	112	100

The chicks were weighed at weekly intervals, and the amount of food consumed recorded. At the end of three months the financial results were calculated.

Financial Results.

High Protein Section—

Total cost of high protein ration for first twelve weeks—£1 5s. 8d.

Total live weight of chicks at three months old—94 lb.

Cost of food to produce 1 lb. live weight—3.28d.

Low Protein Section—

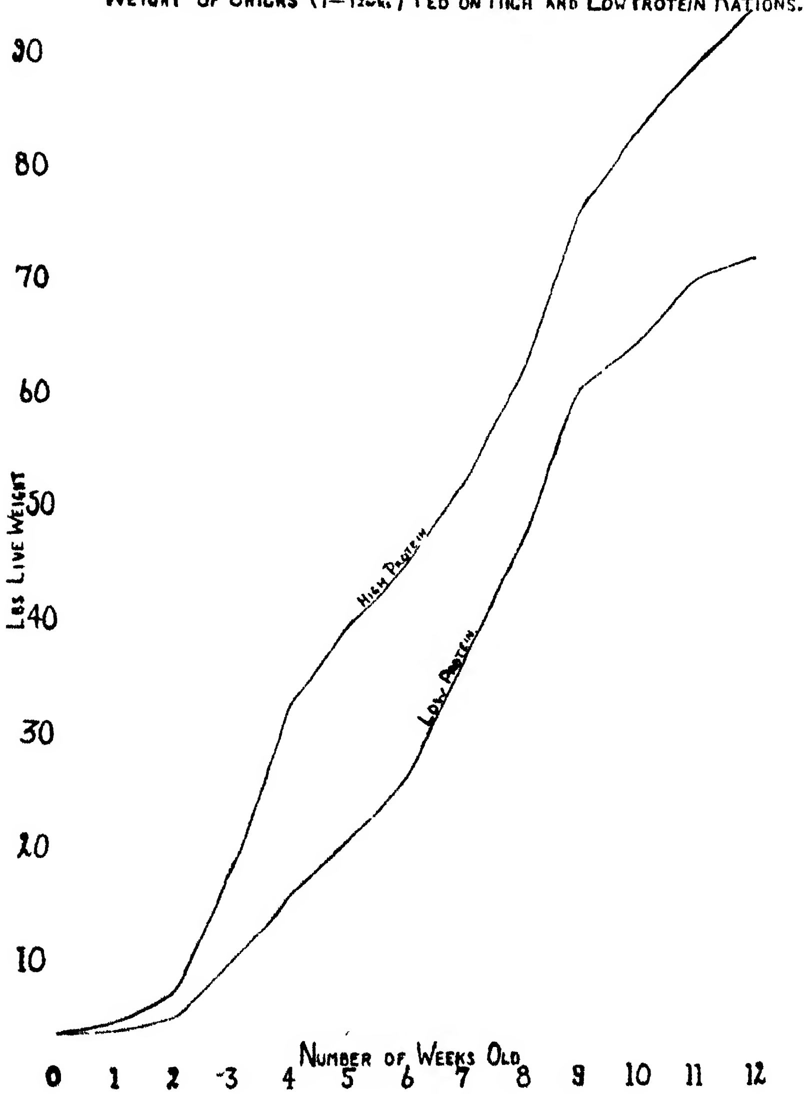
Total cost of low protein ration for first twelve weeks—£1 0s. 2½d.

Total live weight of chicks at three months old—73 lb.

Cost of food to produce 1 lb. live weight—3.32d.

In spite of three casualties in the High Protein Section, the cost of producing a live weight increase was definitely below that of the Low Protein Section.

Graph Showing the Rate of Increase in Live Weight of Chicks (1–12wks.) Fed on High and Low Protein Rations.



The Effect upon the Herbage.

The chicks were allowed to run in grass pens when four weeks old. The pens were of equal size and identical in botanical composition. At the end of twelve weeks the grass in the low protein pen was heavily grazed, and kept in check, whilst the herbage in the high protein run remained untouched, and was allowed to grow into a luxurious hay crop.

The botanical composition of the high protein sward remained the same throughout the whole period, while the clover content of the low protein sward was considerably reduced.

Culling.

The cocks were culled on July 9. Out of the thirty-four birds in the High Protein Section twenty-five cocks were culled compared to twelve cocks from the thirty-seven birds in the Low Protein Section.

The High Protein hens were then put in a cinder run. Eighteen hens were selected from the Low Protein batch and separated for convenience into two equal parts. One batch was put in a cinder run along side the High Protein birds, and the other in a grass run for a comparison in egg laying capacity. In this way the advantages of grass over cinder runs might be estimated. The ration mentioned in Experiment I was gradually introduced.

Egg laying commenced on July 18 in the High Protein section, and on August 2 and 10 in the Low Protein grass and Low Protein cinder pens respectively.

	High Protein Section.		*Low Protein (cinder run).*		*Low Protein (grass run).*	
	No. of Eggs.	*Aver wt. Eggs.* oz.	*No. of Eggs.*	*Aver wt. Eggs.* oz.	*No. of Eggs.*	*Aver wt. Eggs.* oz.
July 18–Aug. 31	310	1.5	146	1.1	142	1.2
September	237	1.7	158	1.7	146	1.8
October	128	2.3	137	2.0	154	2.1
November	154	2.1	128	2.8	125	2.0
December	138	2.1	135	2.0	98	2.0
January	113	2.0	101	2.1	124	2.0
February	142	2.2	97	2.2	120	2.0
March	192	2.8	150	2.1	162	2.0
April	189	2.2	97	2.0	128	2.0
May	127	2.1	99	2.2	116	2.2
	1730	2.0	1248	1.9	1310	1 9

Although the number of birds in each section appears low for accurate experimental results, the above figures show that there is a distinct advantage of feeding a high protein ration as

well as an advantage of a grass run over asphalt when a low protein ration is provided. It is hoped to repeat this experiment on similar lines with a larger number of birds so as to provide financial results.

EXPERIMENT III.

This experiment was carried out on similar lines to Experiment II, except that a Medium Protein ration was included (containing half as much protein as the High Protein ration), the object being to investigate the effect of protein on the laying capacity of young birds in grass runs. Three lots of fifty-two day-old chicks were put in separate brooders on April 30, and at the end of twelve weeks financial results on live weight increase were calculated as before.

Financial Results.

High Protein Section—

Total cost of High Protein ration for first twelve weeks—£2 5s. 4d.

Total live weight of chicks at three months old—125 lb.

Cost of food to produce 1 lb. live weight—4.35d.

Medium Protein Section—

Total cost of Medium Protein ration for first twelve weeks—£2 4s. 0d.

Total live weight of chicks at three months old—120 lb.

Cost of food to produce 1 lb. live weight increase—4.4d.

Low Protein Section—

Total cost of Low Protein ration for first twelve weeks—£2 7s. 2d.

Total live weight of chicks at three months old—88 lb.

Cost of food to produce 1 lb. live weight—5.9d.

Although there was only a slight advantage in feeding a High Protein over a Medium Protein ration, it cost approximately ½d. more to produce 1 lb. live weight increase in the Low Protein section than in the High Protein section.

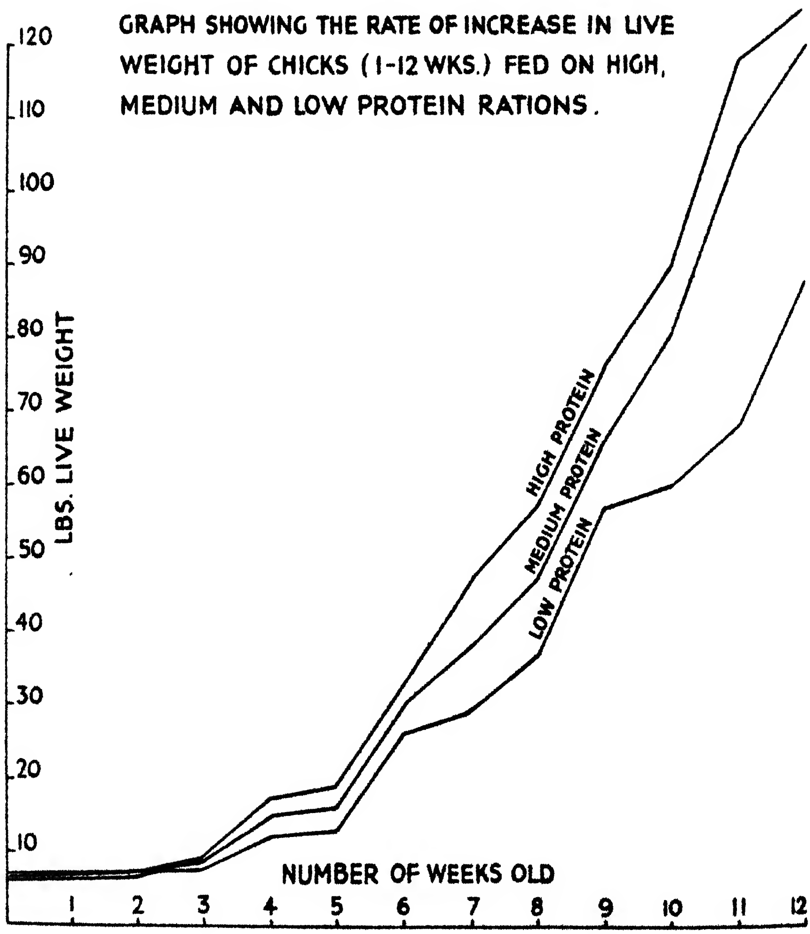
To a poultry farmer of this nature, producing 5,000 table birds per annum at an average weight of 6 lb. per bird, his financial gain when using a High Protein ration in preference to a ration low in protein would amount to approximately £70.

Casualties up to twelve weeks old amounted to four, three and two in the High, Medium and Low Protein sections respectively.

Culling took place in August with the following results :—

	Cocks.	Pullets.
High Protein pen	28	20
Medium Protein pen	26	23
Low Protein pen	18	32

Twenty pullets from each section were then placed in their respective laying houses and gradually changed into their different laying rations (see Experiment II). Dry mash, oyster shell and water were available to the birds at all times, and grain was provided every evening.



The number of eggs and total weight of eggs from each section were recorded daily and the body weight of the birds noted at intervals of three months.

Egg laying results from September, 1935—May, 1936 :—

	High Protein Section.	*Medium Protein Section.*	*Low Protein Section.*
Average weight of birds, August 30, 1935	3.8 lb.	3.6 lb	3 2 lb.
Average weight of birds, May 30, 1936	5 6 lb.	5.5 lb.	5.0 lb.

	High Protein Section.		*Medium Protein Section.*		*Low Protein Section.*	
	No. of Eggs.	*Aver wt. Eggs.* oz.	*No. of Eggs.*	*Aver wt. Eggs.* oz.	*No. of Eggs.*	*Aver wt. Eggs.* oz.
September	45	1.8	10	2.0		
October	106	1.9	59	2.2	32	1.9
November	218	1.7	211	1.9	99	2.1
December	195	1.8	212	1.9	183	1.9
January	290	2.0	314	2.0	269	2.0
February	312	1.9	305	2.0	228	2.1
March	475	2.1	447	2.2	361	1.9
April	333	2.1	274	2.0	220	1.8
May	360	2.0	301	2.0	171	1.8
	2364	1 9	2163	2 0	1563	1.9

	High Protein Section.	*Medium Protein Section.*	*Low Protein Section.*
Amount of food consumed over whole period	610 lb	610 lb	680 lb.
Comparative cost of producing one dozen eggs, mash and corn costing 10/-, 9/6, 9/- per 100 lb respectively	3 7d.	4.4d	5.6d.

The above figures show that birds reach maturity and begin to lay earlier when fed on a high protein ration, and that in the first eight months of the laying period 800 more eggs were produced than in the low protein section. In spite of the low cost of the low protein ration, the cost of producing a dozen eggs was approximately 2d. and 1d. more than in the high and medium protein sections respectively. To a poultry farmer with 1,000 birds of this description a difference of £140 would result when using a high in preference to a low protein ration. Comparing these results with those in Experiment I, it is observed that a high protein ration is more essential for young laying birds than after maturity is reached.

Change in the Botanical Composition of the Sward.

Composition of the original sward :—

	%
Wild White Clover	39
Grass	47
Dandelions	8
Thistles and weeds	6

Composition of sward after sixteen weeks' treatment :—

	High Protein Section.	*Medium Protein Section.*	*Low Protein Section.*
	%	%	%
Wild White Clover	32	64	9
Grass	52	28	86
Dandelions	12	6	4
Thistles and weeds	2	2	1

Here again the low protein birds supplemented their protein deficiency by consuming the clover and weeds, whilst the herbage in the high protein section remained untouched. Intermediate results were obtained throughout the experiment from the medium protein section.

Similar experiments to the above are in progress and are, up to date, providing identical results.

Throughout these experiments there seems to have been a correlation between the number of males produced and the amount of protein added to the ration of the parent birds. Investigations into this matter with larger numbers are now in progress.

THE LABORATORY EXAMINATION OF RAW GRADED MILK.

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University College, Aberystwyth.

The following bacteriological standards for the various classes of raw graded milk in England and Wales were prescribed by the Milk (Special Designations) Order, 1923.

Certified milk must not contain more than 30,000 organisms per ml. and no coliform organisms in 1/10 ml.

Grade A (Tuberculin Tested) Milk and Grade A Milk must not contain more than 200,000 organisms per ml. and no coliform organisms in 1/100 ml.

Other standards and tests have been prescribed in the revised Order which came into force on January 1, 1937. The bacteriological results presented in this paper were obtained during the official examination of graded milk from twelve dairy farms situated within fifty miles of the laboratory. Monthly samples were obtained from six of these farms over a period of ten years and for periods of two to four years in the case of the

others. Samples of one pint (approximately 600 ml.) of morning's milk were taken at random from the delivery vans and forwarded to the laboratory in wooden boxes. The samples from the two Certified producers were sent in ice-boxes. On arrival the bottles were kept at 60°F. until tested at 28 hours after milking.

The technique of examination was according to the recommendations given in the Ministry of Health Memorandum 139/Foods (1928), that is, dilutions of 1/10, 1/100 and 1/1,000 ml. milk were plated on standard agar.

Three tubes containing 10 ml. of bile salt, lactose, peptone water and a Durham's fermentation tube were inoculated each with 1/10 ml. of a Certified sample, and 1/100 ml. of a Grade A sample. Plates and tubes were incubated for 48 hours at 37°C.

In order to obtain more detailed knowledge of the amount of coliform organisms present, dilutions of 1 ml., 1/10th, 1/100th and 1/1,000th ml. were also inoculated.

The conditions of milk production and distribution varied a good deal from farm to farm, but generally they were about the best obtainable in Mid-Wales at this time. The producers were pioneers of clean milk production in their respective districts and as such were most enthusiastic in applying all the knowledge appertaining to the production of low count milk. It is important to note that the utensils on each farm were efficiently steam sterilised. The milk was also cooled immediately after production, but many were unable to reduce the

TABLE I.

Bacteriological results for the Twelve Farms.

Farm Code No.	*Milk Designation.*	*Number of cows in milk.*	*Number of samples examined.*	*Per cent. samples within designation.*
C.	Certified.	26	92	87
L.	,,	35	84	90
A.	Grade A (T.T.)	33	109	88
N.	,,	20	107	87
T.	,,	24	52	79
G.	,,	14	57	95
Y.	,,	15	55	78
B.	,,	18	24	79
V.	,,	20	19	90
D.	,,	25	21	95
La.	Grade A.	22	90	82
P.	,,	20	34	85

temperature below 56°—60° F. during the warmest periods of the year.

The results of the bacteriological examinations demonstrate clearly the care taken in the production of the milk (Table I). The two Certified producers were able to keep within the rather strict standards for this grade in approximately 90 per cent. of the samples. Only 5 per cent. of the samples submitted for examination by two of the Grade A (T.T.) producers failed to attain the desired bacteriological standards. Of a total of 870 samples examined, 87 per cent. attained the prescribed standards.

The satisfactory nature of the results as a whole is clearly shown by the fact that during winter and spring months, bacterial counts under 10,000 per ml. were recorded for 68 per cent. of the samples and that coliform organisms were not detected in 57 per cent. Slightly poorer results were obtained for summer and autumn samples, but even then, only a few samples gave counts over 200,000 per ml., or coliform organisms in 1/100 ml.

TABLE II.

Colony count results, showing seasonal variation.

Quality.	Bacterial Count group per ml.	December–May		June–November.		All Year	
		No. of Samples	Per Cent	No. of Samples	Per Cent	No. of Samples	Per Cent
Excellent .	0 - 10,000	272	63	203	46	475	55
Very Good ...	10,001 - 50,000	94	22	114	26	208	24
Fair	50,001 - 200,000	41	9	79	18	120	14
Poor	200,001 - 500,000	15	4	23	5	38	4
Very Poor ..	Over 500,000	6	2	23	5	29	3
	TOTAL	428	100	442	100	870	100

TABLE III.

Results of tests for Coliform Organisms.

Coliform Organisms Content.	December–May		June November.		Total.	
	No. of Samples.	%	No. of Samples.	%	No. of Samples.	%
Absent in 1 ml	136	57	127	43	263	49
+ 1 ml.	43	18	51	17	94	18
+ 1/10th ml	47	20	66	23	113	21
+ 1/100th ml.	6	3	24	8	30	6
+ 1/1,000th ml.	5	2	25	9	30	6
TOTAL	237	100	293	100	530	100

Practically half the number of samples which failed to attain the prescribed standards were taken during the warm weather of June to August. (Table IV). The lack of facilities for efficient cooling as well as the effect of high temperatures during the transport of the sample can be advanced as possible explanations.

It is interesting to note that in the Milk (Special Designations) Order, 1936, the seasonal effect has been taken into consideration, and a slightly more lenient standard fixed for the summer months.

Thomas and Lewis (1928) and Thomas (1931)) have previously indicated the importance of the influence of seasonal and transit temperature factors in the bacteriological grading of milk.

TABLE IV

Seasonal Distribution of samples failing to attain the prescribed standards.

Season.	*Number of samples that failed to attain bacteriological standards*	*Per Cent.*
Winter. (Dec.-Feb.)	15	13
Spring (Mar.-May)	18	16
Summer. (June-Aug.)	52	46
Autumn. (Sept.-Nov.)	29	25
TOTALS	114	100

The nature of the tests used in this country for the bacteriological grading of milk, whether for advisory or official purposes, has had a considerable influence on the educational methods used in the development of the clean milk movement. Advisory and control laboratories have for the past ten years employed the plate count on standard agar or milk agar, coliform test, methylene blue reduction test, keeping quality at 15° C., and in some cases direct microscopic examination. At least three, and often four of these tests have been used simultaneously. The results thus obtained have been of much greater value to the milk producer and the dairy instructor, than if only one of these tests had been used. Not only is it possible to obtain a general idea of the nature of the micro-flora present when the results of a number of these tests are studied, but a

stricter bacteriological standard is enforced. This is proved by a study of the cumulative effect of the two tests used in the examination of the series of samples under discussion. (Table V). On the results of the plate count and coliform test, 114 samples were below standard. If the plate count alone had been used only 60 per cent. of this number would have failed, and if, on the other hand, the results were judged on the coliform test, only 76 samples (67 per cent.) would be below standard.

TABLE V.

Failure to attain prescribed standard according to test employed.

Failed to attain desired bacteriological standards on:—	*Number of Samples.*	*Per cent.*
Both Colony count and Coliform test	31	27
Colony count only .	38	33
Coliform test only .	45	40
TOTAL	114	100

During the years 1929 to 1936 the pint bottles of morning milk from the twelve farms were tested for fat content. The results available for 500 samples show more than the usual variation. (Table VI). Nearly 17 per cent. were found to be below 3 per cent. fat content. This compares unfavourably with results of examinations of milk from churns. According to a Ministry of Agriculture Bulletin (1930) the results for about 9,700 samples from churns delivered from twenty-five farms at two factories indicate that 7 to 8 per cent. is a maximum figure for the percentage of churn samples to be found under the presumed legal standard of 3 per cent.

On the other hand, 26 per cent. of the bottled milk samples contained over 4 per cent. butter fat. The arithmetic mean for the 500 samples is 3.64 per cent.

TABLE VI.

Fat content of bottled milk.

Butter Fat Content	*Number of Samples.*	*Per Cent.*
Under 2.0 per cent .	10	2.0
2.0—2.9 per cent. ...	74	14.8
3.0—3.9 per cent.	286	57.2
4.0—4.9 per cent. .	99	19.8
5 per cent. and over ..	31	6.2
TOTAL	500	100.0

Unless precautions are taken to thoroughly mix the milk from a number of cows before the commencement of cooling and bottling, variations of this nature can always be expected.

Summary.

1. The results of the bacteriological examination of 870 pint samples of graded milk from twelve farms are given.

2. The prescribed bacteriological standards were attained by 87 per cent. of the samples.

3. Bacterial counts under 10,000 per ml. were recorded for 55 per cent. of the samples.

4. Nearly half the number of samples failing to attain the prescribed standards were taken during June to August.

5. The butter fat content of the bottled milk showed much variation.

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THE COMPARATIVE VALUE OF MILK AGAR AND STANDARD AGAR FOR THE BACTERIOLOGICAL EXAMINATION OF RAW AND PASTEURISED MILK.

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Introduction.

Laboratory methods for controlling the hygienic quality of milk have been in use in the various European countries and American States since the beginning of this century. The necessity for the use of standardised technique was realised fairly early, and in the first report (1910) of the Committee of the Laboratory Section of the American Public Health Association on Standard Methods for the Bacteriological Examination of Milk, details regarding the preparation of standard agar medium are given. Except for the substitution of beef extract for beef infusion, all editions of this publication up to the sixth (1934) are very much on the same lines with regard to the composition of the agar medium used.

With the development of Clean Milk Competitions in England and Wales, the Ministry of Agriculture produced in 1924 a Guide to Clean Milk Competitions in which the technique for the preparation of Standard Agar of similar composition is given. The agar medium recommended in Memorandum 139/Foods, issued by the Ministry of Health in connection with the Milk (Special Designations) Order, 1923, was of the same composition :—

Water	1,000 ml.
Peptone	5 grms
Beef Extract	3 grms.
Agar ...	15 grms.

This so-called standard medium has been subjected to much criticism, and various workers have suggested alternative media. Ayers and Mudge (1920) proposed the addition of milk powder to the agar, but they were then mainly concerned with a simple method for detecting the chief groups of milk bacteria—acid producing, peptonising, alkaline and inert. Norton and Seymour (1926) compared four different media with standard agar, including a modification of the Ayers and Mudge milk powder agar. They found this milk agar to have the best nutritive value for both raw and pasteurised milk bacteria. Demont and Dorner (1931) found that their particular skim milk agar media gave counts approximately 20 to 50 per cent. higher than that of a standard flesh extract peptone agar. McIntosh and Whitby (1931) working with pasteurised milk, obtained much higher counts on a meat extract peptone agar. Hiscox, Hoy, Lomax and Mattick (1932) using standard agar to which sterile separated milk had been added, also found enormous increases in the plate counts of some samples of raw milk and many samples of pasteurised milk over those obtained on standard agar. Devereux (1932) noted the failure of many milk bacteria to grow on plain nutrient agar, and recommended a medium in which yeast extract, peptonised milk and dextrose were incorporated.

As a result of these investigations the fourth edition of the "Guide to the Conduct of Clean Milk Competitions" (1932) recommended the addition of 10 ml. of fresh, raw, cleanly-separated milk to each litre of the agar before autoclaving. Anderson and Meanwell (1933) found that a medium containing 0.5 per cent. sterile milk not only gave a higher count, particularly with pasteurised milk samples, but also diminished discrepancies in the counts between different dilutions. Thomas (1934)

also published results for 265 samples of raw milk and found that the addition of sterile milk to the standard agar had a favourable influence on the number and size of the colonies that developed. The increase in number, however, was not so significant as that obtained by other workers for pasteurised milk.

Bowers and Hucker (1935) during an investigation of possible modifications of the standard agar recommended for use in the Standard Methods of Milk Analysis found that the addition of a fermentable carbohydrate and 0.5 per cent. skim milk increased its efficiency. The medium that was found to give the best results in developing all the usual and unusual types of bacteria of samples ordinarily examined in milk control laboratories was one containing 0.5 per cent. Tryptone (Difco), 0.1 per cent. glucose, 0.5 per cent. skim milk and 1.5 per cent. agar. Wilson *et al* (1935) confirmed the above investigations and recommended a medium containing yeast extract, 1 per cent. fresh whole milk, peptone, and washed shredded agar. Provan (1936) published results for 128 samples of pasteurised milk obtained from five creameries in the Midlands. He showed that the effect of the addition of milk to the medium was greatest with milks having a high count.

Barkworth (1936), using data supplied by Provan and Thomas, as well as his own figures, carried out a statistical examination of the significance and comparative value of milk agar for 398 raw and 124 pasteurised samples. He was able to show that the use of 1 per cent. milk agar gave a significant increase in colony numbers for both raw milk and pasteurised milk at all levels of count. There was a marked increase with pasteurised milk on the 1/100 and 1/1,000 ml. plates. Milk agar also gave better colony growth, tending to more rapid and accurate counting. Memorandum 139/Foods (January, 1937), issued by the Ministry of Health in connection with the Milk (Special Designations) Order, 1936, recommends for the testing of pasteurised milk an agar medium containing 1 per cent. whole milk, 0.3 per cent. yeastrel, 0.5 per cent. peptone, and 1.5 per cent. agar. It is anticipated that the Seventh Edition of the American "Standard Methods of Milk Analysis" will contain modifications in this direction.

Technique Used.

In the present investigation a series of 265 samples of raw milk from thirty-four farms and 58 samples of pasteurised milk from three creameries has been studied. The samples

were forwarded in six ounce bottles (not in ice boxes), kept at 60°F. on arrival at the laboratory, and plated within 24-28 hours of production or pasteurisation on standard agar as well as on agar containing 1 per cent. separated milk. Three plates of 1/10, 1/100 and 1/1,000 ml. dilutions were used for each method, incubated at 37° C. for forty-eight hours, and an illuminated chamber and tally counter was used for counting colonies. Plates containing the nearest to 300 colonies were taken as being the most satisfactory.

Results Obtained.

The ratio of the colony counts on the two media was worked out separately for each sample. When the results are arranged according to frequency distribution (Tables I and II) it is observed that the milk agar counts are distinctly higher for both the raw and pasteurised milk samples. The favourable influence of milk agar is much more marked in the case of pasteurised milk. Of the raw milk samples tested, 81 per cent. showed higher counts with milk agar, the corresponding figure for pasteurised milk being 98 per cent. If the possible limit of error of sampling be placed at 40 per cent., it is found that at

TABLE I.

Ratio of colony count on milk agar to that on standard agar.

Ratio.	*Raw Milk.*		*Pasteurised Milk.*	
	No. of samples.	*Per cent.*	*No. of samples.*	*Per cent.*
0 — 0.99	49	19	1	2
1.00— 1.39	91	35	10	19
1.40— 1.99	60	23	13	24.5
2.00— 2.99	28	11	13	24.5
3.00— 3.99	14	5	5	9
4.00— 4.99	8	3	1	2
5.00— 9.99	12	4	4	7
10.00—14.99	0	0	3	6
15.00 and over ..	0	0	3	6
Total ..	265	100	53	100

TABLE II.

	Per cent. samples for which the milk agar count exceeded the standard agar count by a ratio of:—						
	1	*1.4*	*2*	*3*	*4*	*5*	*10*
Raw milk	81	46	23	12	7	4	0
Pasteurised milk	98	79	51	30	21	19	12

least 46 per cent. of the raw milk samples, and 79 per cent. of the pasteurised samples show a significantly higher count on milk agar.

TABLE III.

Ratio of the count on milk agar to that on standard agar. Arithmetic mean of all ratios.

	No. of Samples.	*Ratio.*
Raw milk . . .	265	1.9
Pasteurised milk	53	4.8

When the arithmetic mean of all the ratios is taken (Table III), milk agar produced a count, on the whole, nearly twice that obtained on standard agar in the case of raw milk and over four-and-a-half times greater with the pasteurised samples. Arranging the ratios according to the bacterial content of the samples shows the striking effect of milk agar on the results obtained with high count milk (Table IV). This is again more marked in the case of pasteurised milk.

TABLE IV.

Influence of addition of milk to standard agar. Samples arranged according to bacterial content.

	Raw Milk.		*Pasteurised Milk*	
Colony count per ml on milk agar.	*No. of Samples.*	*Ratio.*	*No. of Samples.*	*Ratio.*
0— 1,000	25	1.3	0	—
1,001— 10,000	68	1.2	7	2.5
10,001— 100,000	61	2.0	25	3.4
100,001 —1,000,000 . .	96	2.0	17	3.3
Over 1,000,000 .	15	2.0	1	8.3

The above results are compared with those obtained by Bowers and Hucker (1935) and Wilson *et al* (1935) in Table V. The weighted means of all the ratios obtained in the three groups of series are 1.7 for raw milk and 3.7 for pasteurised milk.

Mastitis Milk.

In order to find whether the milk agar medium is suitable for the growth of such parasitic organisms as mastitis streptococci, samples were drawn under aseptic conditions directly into sterile bottles from the udders of twelve cows showing clinical and microscopic evidence of streptococcic mastitis. The samples were plated on milk agar in 1/100, 1/1,000 and 1/10,000

TABLE V.

Investigation.	*Comparison.*	*Raw Milk.* No. of Samples	*Raw Milk.* Ratio.	*Pasteurised Milk.* No. of Samples	*Pasteurised Milk.* Ratio.
Bowers and Hucker (1935)	Skim milk agar with A.P.H.A. standard agar.	92	1.2	75	1.4
Wilson *et al* (1935)	Whole milk agar with Ministry of Health standard agar ...	23	1.2	67	1.9
	Whole milk agar with A.P.H.A. standard agar	67	1.9	264	1.6
Aberystwyth 1934-6	Skim milk agar with Ministry of Health standard agar ...	265	1.9	53	4.8
Weighted mean ...		447	1.7	459	3.7

ml. dilutions within twelve hours of milking, and incubated at 37° C. for seventy-two hours. An illuminated chamber and a magnifying glass of 4 inches focal length were used for counting. The colonies were generally of pin-point size, even in some low count samples. The counts obtained are given in Table VI. The bacterial content of normal healthy udders does not generally exceed 5,000 colonies per ml. The results obtained show that at least a considerable proportion of the mastitis streptococci have grown on the milk agar, particularly in the cases of acute

TABLE VI.

Cow. No.	*Microscopic appearance of sediment.*	*Colony count per ml.*	*Appearance of colonies.*
M7	Long chained cocci abundant.	11,000,000	Pinpoint
M1		3,000,000	,,
M4		1,400,000	,,
M11		1,000,000	,,
M3		730,000	,,
M2		300,000	,,
M8	Very few cocci in samples marked with an *	240,000	—
M9		*120,000	—
M12		82,000	Pinpoint
M13		*40,000	,,
M10		*10,000	—
M5		*4,300	Pinpoint

mastitis. In order to prove whether all the viable mastitis streptococci can grow on this medium a comparison with blood agar is needed.

Growth of Thermophilic Milk Bacteria.

A recommendation is made in the Sixth Edition of the American "Standard Methods of Milk Analysis" (1934) that a so-called Yeast Dextrose agar be used for the detection of thermophilic bacteria. A dehydrated form of this agar having the following composition was compared with milk agar.

Bacto Beef Extract	0.30 per cent.
Bacto Peptone . . .	0.50 per cent.
Glucose	0.10 per cent.
Bacto Tryptone .. .	0.25 per cent.
Bacto Yeast Extract	0.10 per cent.
Agar	1.50 per cent.
Distilled water	

Fifteen samples of milk taken on different days towards the end of the pasteurising run from a plant known to contain thermophiles were plated in 1/10, 1/100 and 1/1,000 ml. dilutions on both media in duplicate and incubated for forty-eight hours at 55° C. and at 63° C. Colony counts ranging from 2,000 to 250,000 per ml. were obtained. Higher counts were obtained on the milk agar for fourteen samples. This was very striking in the case of the counts at 63° C.—a temperature at which true thermophiles only can grow (Table VII). The results from this rather small series show clearly that milk agar can be usefully employed for stimulating the growth of thermophilic bacteria.

TABLE VII.

Ratio of the colony count on milk agar to that on yeast dextrose agar. (Arithmetic mean of all ratios).

	Temperature of Incubation.	*No. of Samples.*	*Ratio.*
Pasteurised Milk.	55° C. 63° C.	15 15	8.2 14.5

Discussion.

Memorandum 189/Foods (1937) issued by the Ministry of Health (London) recommends that the Coliform test and the Methylene Blue Reductase test be used for the routine official examination of raw designated milk (Tuberculin Tested and Accredited).

Colony counting on milk agar has been, however, retained as the official method of grading designated Pasteurised milk. In addition it is obvious that for investigational and advisory work on raw and pasteurised milk the use of an agar medium will always be necessary. Agar, containing peptone and beef extract without a fermentable carbohydrate remained as the standard medium for the examination of milk for over twenty years, since it was generally believed that it developed a constant proportion of the organisms present. During recent years it has been realised that standard agar is not suitable for the growth of mastic streptococci, as well as the thermophilic bacteria of milk. Furthermore, it is evident that the various kinds of lactic acid streptococci cannot develop to any appreciable extent in a medium devoid of a fermentable carbohydrate. As Hiscox, Hoy, Lomax and Mattick (1932) state, the method which gives the highest count whilst still allowing the test to be simple and inexpensive, may be expected to prove the most satisfactory for the general examination of milk. For routine and advisory work this will still be the attitude of the dairy bacteriologist whether he is concerned with the examination of raw or pasteurised milk.

Apart from the investigation of the public health safety of milk, where it is necessary to rely on animal innoculation, bacteriological grading is mainly concerned with the keeping quality and pasteurisability of the milk. In order to investigate the many aspects of these two points either at the farm or factory, the dairy bacteriologist will be concerned with :—

(*a*) Tests for the presence of mastitis organisms in raw milk.
(*b*) Tests for the sterility of dairy utensils and equipment at farm and factory.
(*c*) Detection of thermoduric and thermophilic bacteria.
(*d*) Detection of the coliform organisms of raw and pasteurised milk.

The quickest and simplest way to carry out the initial parts of such work is to plate out various dilutions on milk agar or on selective media such as blood agar, allied with direct microscopic examination of the milk.

Summary.

The results of this investigation indicate that the addition of 1 per cent. skim milk to standard agar increased the colony count by a ratio of 1.9 in raw milk samples and by a ration of 4.8 in pasteurised milk.

An examination of mastitis milk has shown that parasitic streptococci are able to grow as pinpoint colonies on milk agar. Colony counts of over ten millions per ml. were obtained. No comparison has been made with blood agar.

Milk agar was found to be much more suitable than yeast dextrose agar for the growth of thermophilic bacteria at 55° C. and particularly so at 63° C.

An inexpensive medium of this nature which can be prepared by a comparatively simple method is still required for advisory and investigational work in bacteriological laboratories.

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THERMOPHILIC BACTERIA IN RAW AND PASTEURISED MILK.

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Introduction.

Thermophilic bacteria have been shown to be of great importance, causing certain defects in canned food and sugar, and they are of considerable significance in the dairy industry. The optimum temperature for growth is around 55°—60°C. Most thermophilic bacteria are aerobic or anaerobic spore formers,

and strains have been studied which have shown growth after boiling for several hours.

Much confusion has existed concerning the definition of thermophilic bacteria. Academically the term may be used for any micro-organism of unusually high optimum temperature of growth, for example, *Streptococcus thermophilus*, and *Lactobacillus thermophilus*. Food bacteriologists restrict the use of the term to organisms capable of growing at 55°C., whilst dairy bacteriologists now use it only for bacteria which grow at the temperature of holder pasteurisation, namely 63°C. Though *S. thermophilus* and *L. thermophilus* are thermoduric (heat resisting) and a large proportion of their cells will survive heating for half an hour at 63°C., there is no evidence that they are thermophilic according to the modern usage of the term.

Thermophilic bacteria were first isolated from soil, manure, water, air, dust and hay. Miquel (1879) isolated a spore forming bacterium which grew at high temperatures (42° to 70°C) from water derived from the Seine. This started a search for similar bacteria in a great variety of substances. A comprehensive review of this early literature is given by Robertson (1927).

The study of thermophilic bacteria became important in dairy bacteriology when it was realised that they grew profusely in pasteurising plants under certain conditions and increased the 37°C. colony counts of pasteurised milk. Leichmann (1894) was among the first to recognise that he had isolated from milk a bacterium with thermophilic properties. By 1900 a number of workers had isolated thermophilic bacteria from milk and some had noted the curdling of milk held at high temperatures. It was not until 1920 that growth of bacteria in pasteuring plants at 63°C. was definitely recognised. Breed (1932) has reviewed the literature dealing with thermophilic bacteria in milk pasteurised by the holder process. Yale and Kelly (1933) were able to show that the temperatures used in high-temperature, short-time pasteurisation (70°—72°C.) are above the optimum temperature for the growth of thermophiles.

Some thermophilic bacteria have a wide range of growth temperatures so that the term *facultative thermophile* is used for organisms whose growth range is as low as 37°C. on the one hand and 63°C. or higher on the other. Such *facultative thermophiles* will continue to grow slowly even at normal room temperature, as has been demonstrated by Hansen (1933). The term *obligate thermophile* is reserved for those thermophiles which cannot grow at a temperature as low as 37°C. Hansen (1932) showed by

feeding experiments with Guinea-pigs that his strains of thermophiles were not pathogenic, and that pasteurised milk containing thermophiles is probably not harmful for human consumption. The presence in large numbers, however, of factultative thermophiles, leads to rapid deterioration of the quality of the milk, and is an indication of faults in the process of pasteurisation or management of the plant. Prickett and Breed (1929), Yale (1929), and Yale and Breed (1930) have summarised the conditions in the operation of holder pasteurising plants that favour the development of thermophilic bacteria. They are as follows:—(1) Repasteurisation. (2) Prolonged holding of milk in vats or in blind ends of piping at pasteurisation temperatures. (3) Continuous use of long-flow holders or vats for more than two to five hours without flushing out equipment with hot water. (4) Passage of hot milk through filter cloths for more than one to two hours. (5) Presence of foam on milk which does not pass on when the vats are emptied at the end of each 30-minute period. (6) Growth of thermophiles on the walls of equipment and in milk deposits on equipment.

Thermophilic bacteria in raw milk.

Thermophiles are rare in clean raw milk, but milk heavily contaminated with bacteria derived from hay, silage, straw, cattle food and cow manure may show the presence of a number of heat loving organisms. Adams and Harding (1924) were able to detect the presence of organisms capable of growing at 63°C. in 28 per cent. of samples of common raw milk. Tanner and Harding (1926) reported thermophilic bacteria, though not numerous, in all samples of raw milk examined. These forms of bacteria were also demonstrated in many samples of milk obtained direct from the udder, but only a few colonies appeared on their plates, and were justly attributed to air contamination. Prickett and Breed (1929) found that these bacteria occurred in such small numbers in churns of fresh milk as delivered to a pasteurising plant, that incubation of 10 ml. samples at 63°C. for three days showed thermophilic bacteria in only 26 out of 180 individual churn samples from 60 farms. Yale and Breed (1930) found agar plate counts at 63°C. of raw milk samples to be usually under 500 per ml. Some exceptions were noted, indicating that unusual conditions may produce a high thermophilic count in raw milk. The return of unsterile moist churns to the producers proved to be one of these conditions. Work carried out by House and Mattick (1931) in this country

confirmed the opinion that thermophilic organisms were rare in clean raw milk. Hansen (1929) confirmed the work done by Tanner and Harding on aseptically drawn milk. Milk was obtained direct from 118 cows, one sample from each quarter. A total of 836 such samples were plated on a special yeast extract, glucose, tryptone agar, and inoculated at 56° C. or at 62° C. Only sixteen colonies were obtained at 62° C., and these were considered to be due to dust and air contamination. Yale and Kelly (1933) obtained colony counts of thermophiles at 62° C. for 125 samples of raw milk entering the pasteurisers at nine plants, ranging from less than ten to 4,500 per ml., with 85 per cent. of the counts less than 100 per ml. Counts higher than 100 per ml. were mostly due to the addition of pasteurised milk for repasteurisation.

Methods Used.

In the present investigation raw milk samples from seventy-nine farms and pasteurised milk from three factories were studied during the years 1930 to 1935. In all, 203 raw milk samples and eighty-six holder pasteurised samples were obtained in ten different series covering all seasons during this period (Table I).

Clean and heavily contaminated raw milk was examined. For example, of the fifty-six samples comprising Series 3, 46 (82 per cent.) gave plate counts at 37° C. under 10,000 per ml., whilst practically half the samples in Series I and Series IV gave counts at 37° C. over 100,000 per ml. The pasteurised samples are likewise of two kinds; a few samples from Plant A—which gave no indication of faults in the process of holder pasteurisation (either on inspection of the plant or as a result of bacteriological examination of the milk), and eighty samples from Plants B and C heavily contaminated with thermophiles. Many faults were observed in the process employed at these two plants, including repasteurisation.

Samples were forwarded to the laboratory in 6 oz. bottles, where they were kept at 60° F. until examined at 24-48 hours after milking or pasteurisation. The pasteurised milk samples were taken from ten-gallon churns which contained milk which had been pasteurised and cooled towards the end of the day's run.

Breed (1932) and his associates at the New York Agricultural Experiment Station, Geneva, found the direct microscopic examinations of pasteurised milk to be of value in demonstrating the presence of thermophilic bacteria, particularly when used in conjunction with agar plates incubated at 55° or 63° C. This method

TABLE I.

RAW MILK.

COLONY COUNT PER ML.—MILK AGAR.

3 days at 37°C

Series.	Source.	Season.	0	1 to 10	11 to 100	101 to 1,000	1,001 to 10,000	10,001 to 100,000	100,001 to 1,000,000	Over 1,000,000	Number of Samples.
1	Farm A.	Winter, 1930–1 .				2.	9.	6.	8.	8.	33.
2	Random Samples .	Summer, 1932 ..						5.	13.	3.	21.
3	Farm A.	Winter, 1932–3 .				6.	40.	7.	1.	2.	56.
4	Farm A.	Winter, 1933–4 .					7.	4.	5.	5.	21.
5	Farm B.	Winter, 1933–4 .				1.	3.	7.	4.	1.	16.
6	Random Samples ..	Winter, 1933–4 .						5.	5.	—	10.
7	Random Samples .	All year, 1935 ..				8.	16.	10.	9.	3.	46.
	TOTAL NUMBER OF SAMPLES .					17.	75.	44.	45.	22.	203.
	PASTEURISED MILK.										
8	Plant A.	May, 1935 . .						6.			6.
	PASTEURISED MILK.										
9	Plants	Winter, 1930–1 .				1.	22.	9.	15.	8.	55
10	B. and C.	All year, 1935 ..					3.	5.	15.	2.	25.
	TOTAL NUMBER OF SAMPLES					1.	25.	14.	30.	10.	80.

2 days at 55°C.

Series.	0	1 to 10	11 to 100	101 to 1,000	1,001 to 10,000	10,001 to 100,000	100,001 to 1,000,000	Over 1,000,000	Number of Samples.
1	2.	4.	7.	15.	4.	1.			33.
2									0.
3	[illegible]								0.
4									0.
5	[illegible]								0.
6									0.
7	3.	32.	5.	1.					40
TOTAL NUMBER OF SAMPLES	10.	36	12.	16.	4.	1.			79.
8	1.	1.		4.					6.
9			1	10.	34.	8	2.		55.
10				1.	8	12	4.		25.
TOTAL NUMBER OF SAMPLES			1.	11.	42.	20.	6.		80.

2 days at 63°C.

Series.	0	1 to 10	11 to 100	101 to 1,000	1,001 to 10,000	10,001 to 100,000	100,001 to 1,000,000	Over 1,000,000
1								
2	15.	3.	1.	2.				
3	51.	1	1					
4	17	3.	1.					
5	14.	2						
6	4.	5	1.					
7	28	14	3.	1.				
TOTAL NUMBER OF SAMPLES	132	28	7.	3				
8	3	1	1.	1				
9								
10				4.	6.	11.	4.	
TOTAL NUMBER OF SAMPLES				4.	6.	11.	4	

of examination was used for pasteurised milk, a note being made of the presence of excessive numbers of scattered or grouped long, thin " bent " rods.

All samples were plated out in 1/10, 1/100 and 1/1,000 ml. dilutions on milk agar and incubated at 37° C. for three days, in order to obtain some idea of their hygienic quality. The milk was also plated out in duplicate on milk agar and yeast dextrose agar (see previous article) and incubated for two days at 56° C. and at 63° C. Since the growth of thermophiles was found to be markedly superior on milk agar—the counts for this medium only are given in this paper. The raw milk was plated in 1 ml. and 1/10 ml. dilutions and the pasteurised milk in 1/10, 1/100 and 1/1000 ml. dilutions. Thirty ml. of the medium were poured for each plate incubated at 55° or 63° C. The atmosphere in the incubators at these temperatures was kept as moist as possible. Control plates were poured daily and incubated at the three temperatures. Colonies were counted with the aid of an illuminated chamber, a hand-lens and a tally counter.

Twenty ml. of milk were placed in sterile 6 in. × $\frac{5}{8}$ in. test tubes and 1 ml. of a (1 in 400) solution of methylene blue added. A concentration of methylene blue in milk of approximately 1/300,000 was thus obtained. Sterile rubber bungs were inserted in the tubes and the mixture was inverted twice before placing in water baths at 55° and 63° C. They were examined for reduction at twenty-four and forty-eight hours but not inverted on examination.

The type of fermentation was noted at forty-eight hours, the tubes were then well shaken and a microscopic examination carried out.

Results Obtained.

Microscopical examination of the pasteurised milk on arrival at the laboratory showed in 76 per cent. of the samples from Plants B and C an excessive number of characteristic rods, some showing spores. Thermophilic rods were not detected in any of the samples received from Plant A.

An examination of the results of the colony growth at 37°, 55° and 63° C. (Tables I, II, III, and IV) indicates that :—

(1) One-third of the raw milk samples were heavily contaminated with mesophilic bacteria (37° C. count). Organisms able to grow at 55° C. were found in 87 per cent. of the samples, but only 26 per cent. showed any appreciable number of colonies (over 100 per ml.). True thermophiles capable of growing at

TABLE II.

Percentage frequency distribution of bacterial counts.

Plate Count per ml. (*Milk Agar*).	3 *days at* 37°C.			2 *days at* 55°C.			2 *days at* 63°C.		
	Raw Milk.	*Pasteurised Milk*		*Raw Milk*	*Pasteurised Milk.*		*Raw Milk.*	*Pasteurised Milk.*	
		Plant A.	*Plants B. and C.*		*Plant A.*	*Plants B. and C.*		*Plant A.*	*Plants B. and C.*
(*No. of Samples*).	203.	6.	80.	79.	6.	80.	170.	6.	25.
No growth	0.	0.	0.	13.	16.	0.	78.	50.	0.
1 — 10	0.	0.	0.	46.	17.	0.	16.	17.	0.
11 — 100	0.	0.	0.	15.	0	1.	4.	17.	0.
101 — 1,000	8.	0	1.	20.	67.	14.	2.	16.	16.
1,001 — 10,000	37.	0.	31.	5.	0.	53.	0.	0.	24.
10,001 — 100,000 ..	22.	100.	18.	1.	0.	25.	0.	0.	44.
100,001 — 1,000,000	22.	0	38	0.	0.	7.	0	0.	16.
Over 1,000,000	11.	0.	12.	0.	0.	0.	0.	0.	0.
TOTAL	100.	100.	100	100	100.	100.	100.	100.	100.

63° C. were detected in 22 per cent. of the samples, but only very few (2 per cent.) gave counts of over 100 colonies per ml.

(2) The milk examined from Plant A was within the bacteriological standard fixed for pasteurised milk (less than 100,000 bacteria per ml.). This plant was not heavily contaminated with thermophiles, only 16 per cent. of the samples giving counts of over 100 per ml. at 63 C.

(3) The milk from Plants B and C was of poor hygienic and keeping quality. Only half the samples attained the bacteriological standard for pasteurised milk, whereas counts of over one million per ml. at 37 C. were recorded for 12 per cent. of the samples. True thermophiles growing at 63° C. were found in all samples; 60 per cent. showing counts over 10,000 per ml. at this temperature.

(4) Incubation of suitable dilutions of raw and pasteurised milk in milk agar at 63° C. detected the presence of thermophiles, and was preferable to incubation at 55° C, since the former gave a more definite assurance of bacterial growth at the temperature used in the holder pasteurisation process.

TABLE III.

Geometric mean of colony counts on milk agar (all samples).

	Mean Count per ml. at:—		
	37° C.	*55° C.*	*63° C.*
Raw Milk	10,000	21	2
Pasteurised (Plant A)	34,000	37	4
Pasteurised (Plants B and C)	97,000	8,700	13,000

TABLE IV.

Arithmetic mean of colony counts on milk agar.
(Series 7, 8, and 10 only).

	No. of Samples.	*Mean Count per ml. at:—*	
		55° C.	*63° C.*
Raw Milk	46	8	1
Pasteurised (Plant A)	6	133	102
Pasteurised (Plants B and C)	25	62,200	48,100

Over one half the raw milk samples and one third of the pasteurised samples from Plant A did not reduce Methylene Blue at 63° C. in forty-eight hours. On the other hand, all the samples examined from Plants B and C were reduced within

twenty-four hours. (Table V). It was observed that some of the pasteurised samples were reduced in a much shorter period, reduction times under six hours being recorded. Reduction within twenty-four hours was only rarely observed in raw milk.

Samples containing any appreciable number of thermophiles as indicated by the plate count, generally produced marked

TABLE V.

Methylene Blue Reduction at 63° C.

Reduction time.	Raw Milk.	Pasteurised Milk.	
		Plant A.	Plants B and C.
Reduction in 24 hours	7	3	25
Reduction in 48 hours . . .	12	1	0
No reduction in 48 hours . .	27	2	0
Total No. of samples	46	6	25

Percentage distribution.

	Raw Milk.	Pasteurised Milk.	
		Plant A.	Plants B and C.
Reduction in 24 hours ...	15	50	100
Reduction in 48 hours . . .	26	17	0
No reduction in 48 hours . .	59	33	0
	100	100	100

peptonisation in the tubes of milk held at 55° C. or 63° C. within twenty-four hours, while few tubes produced acid or sweet curdling. All the thermophile contaminated pasteurised samples from Plants B and C were strongly fermented in forty-eight hours at 63° C., whereas only 24 per cent. of the raw milks were fermented. (Table VI).

All the tubes fermented at 55° and 63° C. were characterised by the presence of numerous long, thin, slightly curved rods or shorter, thicker rods in pairs or short chains. Large numbers were generally present per microscopic field and counts ranging from 500,000 to a few hundred million per ml. were obtained by the Breed Microscopic Method. A number of tubes which did not indicate any visual fermentation were found to contain an abundant micro-flora on microscopic examination. The presence

of a large number of organisms (say 5,000,000 and over per ml., that is an average of ten or over per field) in milk held for forty-eight hours at 63° C. was found to be the most sensitive method for detecting the presence of thermophiles. It does not, however, give any indication of the number present in the milk before incubation. Positive results at 63° C. were obtained with 30 per cent. of the raw milk samples, 33 per cent. of the efficiently pasteurised milk and for all the inefficiently pasteurised milk. (Table VII).

TABLE VI.

Fermentation at 55° C. and 63° C.

Fermentation.	*48 hours at 55° C.*			*48 hours at 63° C.*		
	Raw Milk	*Pasteurised.*		*Raw Milk*	*Pasteurised.*	
		Plant A.	*Plant B and C.*		*Plant A.*	*Plant B and C.*
No Fermentation	71.	3.	16.	130	3.	0.
Curdled	0	0.	3.	6.	0.	2.
Peptonised	8.	3.	59.	34.	3.	23.
Total Samples	79.	6	78.	170.	6.	25.

Percentage frequency table.

Fermentation	*48 hours at 55° C.*			*48 hours at 63° C.*		
	Raw Milk	*Pasteurised.*		*Raw Milk*	*Pasteurised.*	
		Plant A.	*Plant B and C.*		*Plant A.*	*Plant B and C.*
No Fermentation	90.	50.	20.	76.	50.	0.
Curdled	0.	0.	4.	4.	0.	8.
Peptonised	10.	50.	76.	20.	50.	92.
Total Samples	100.	100.	100.	100.	100.	100.

Taking the results of the five tests into account (Table VIII) it will be seen that between 20 and 30 per cent. of the raw milk samples contained thermophiles, but that very few contained any significant number. House and Mattick (1931) were able to detect thermophiles by the fermentation test at 63° C. in 70 per cent. of sixty-three ordinary commercial raw milks, but only in 3 per cent. of sixty-seven samples of clean raw milk. They state

TABLE VII.

Microscopical examination after fermentation for forty-eight hours at 55° C. and 63° C.

	55° C.			63° C.		
	Raw Milk	*Pasteurised.*		*Raw Milk*	*Pasteurised.*	
		A.	*B. & C.*		*A.*	*B. & C.*
No organisms	23.	2.	0.	105.	4.	0.
Many organisms	23.	4.	25.	14	2.	25.
Total Samples	46.	6.	25.	119.	6.	25.

Percentage frequency table.

	55° C.			63° C.		
	Raw Milk	*Pasteurised.*		*Raw Milk*	*Pasteurised.*	
		A.	*B. & C.*		*A.*	*B. & C.*
No organisms	50	33.	0.	70.	67.	0.
Many organisms	50.	67.	100.	30.	33.	100.
Total	100.	100.	100.	100.	100.	100.

TABLE VIII.

Per cent. samples showing presence of thermophiles at 63 C.

Test.	*Raw Milk.*	*Pasteurised Milk.*	
		Plant A.	*Plants B and C.*
1. Microscopical examination on arrival at laboratory	—	0	76
2. Plate count (1 or more colonies per ml.)	22	50	100
Plate count (over 100 colonies per ml.) ...	2	16	100
3. Methylene Blue Reduction in 24 hours ...	15	50	100
4. Fermentation in 48 hours ..	24	50	100
5. Microscopical examination of milk held at 63° C. for 48 hours ..	30	33	100

that their results indicate that the more carefully the milk is handled the less danger there is of the presence of thermophilic bacteria. The results obtained with clean and contaminated milk studied during the course of the present investigation confirms their findings (Table IX). The poor quality milk examined (fifty-two samples) did not, however, contain many thermophiles, only three samples producing over one hundred colonies per ml. at 63° C.

TABLE IX.

Comparison of thermophilic flora of clean and contaminated raw milk.

Class.	*Incubation at 37° C.*			*Incubation at 63° C.*			
	Per cent samples with colony counts per ml. of:—		*Per cent samples with Coliform Organisms present in 1/1000 ml*	*Per cent. samples with colony counts per ml. of:—*		*Per cent. samples fermented in 48 hours.*	*Per cent. samples positive on Microscopic Examination.*
	Under 10,000.	*Over 100,000.*		*1 or more*	*100 or more.*		
CLEAN MILK. (Series 3.) 56 Samples.	82	5	2	4	0	0	21
POOR QUALITY MILK. (Series 2, 4, and 6.) 52 Samples.	13	60	67	30	6	63	71

Source of Origin of Thermophiles in Raw Milk.

Hay, straw, silage and bran were obtained from Farm A and examined for the presence of thermophiles. Suspensions of the materials were made in sterilised water, plated out on milk agar, and inoculated into sterile milk. Of twelve samples tested, all produced colonies on milk agar, and marked peptonisation in the sterile milk when incubated for forty-eight hours at 63°. Numerous rods and spores were detected in all the peptonised milks.

Eight samples of cow manure taken from the cowshed at different times during winter and examined in the same way, produced 150 to 2,000 colonies per gram. The colonies were generally found to be composed of spore forming rods, though three colonies of Actinomyces were observed.

The presence of thermophiles on vegetable material suggests that the original source of these organisms is the soil. In any case, it is quite an easy matter particularly under unhygienic conditions, for the raw milk to be seeded with a small thermo-

philic inoculum along with the heavier mesophilic bacterial contamination. Where such milk is pasteurised under uncontrolled conditions, the organisms may be held for a few hours daily at 50° to 63° C., thus leading to their development in enormous numbers.

Some observations on the types of Thermophilic Bacteria isolated.

A number of cultures of the thermophilic, aerobic, spore-forming bacteria were isolated from raw and pasteurised milk and studied with reference to their morphology, colony growth on milk agar, and growth in litmus milk at different temperatures.

Morphologically there was very little variation in their appearance. The main type was a thin longish rod, often in pairs with a rather characteristic bend or curve. Some cultures were composed of thicker rods, with shadow forms abundant. Most of the organisms were highly pleomorphic, long curved chains or filaments being generally seen in cultures older than three days. The majority of young cultures were Gram negative, though Gram positive forms were found. Spores were mainly terminal or subterminal.

The colonies on milk agar varied in size from pin-point types to large spreading surface colonies covering half the area of the petri dish. They were either greyish white or glistening white in colour, though some slightly yellow types were observed. Growth on milk agar slopes was often more luxuriant at 55° than at 63°. Some types died off at both temperatures on milk agar and yeast dextrose agar in three to five days. Other cultures kept their vitality for weeks on agar media. The facultative thermophilic cultures produced slight growth on milk agar slopes at 37° in four days, but no growth at 22° within fourteen days.

A few of these cultures showing growth on agar at 37° were inoculated into litmus milk and incubated at 37° and 22°. Three cultures produced slight acidity at 37° in nine days, but no fermentation was observed at 22°.

Summary.

(1) The presence of thermophilic bacteria in raw and pasteurised milk has been studied by means of five tests, namely: direct miscroscopic examination of pasteurised milk, colony count at 55° and 63° C., methylene blue reduction at 55° and 63°, fermentation in forty-eight hours at 55° and 63°, and microscopic examination after incubation at these temperatures.

(2) It is shown that the methylene blue reduction test combined with the fermentation test at 63° C. are the most sensitive methods of detecting the presence of thermophiles.

(3) Quantitative results can be best obtained by plating suitable dilutions on milk agar and incubating at 63° C. for two days.

(4) Direct microscopical examination is useful as a quick preliminary method of examination for thermophiles in pasteurised milk.

(5) A comparison of the results obtained at 55° and 63° C. shows that the latter is the best temperature for the examination of milk thermophiles. A greater number of positive results are generally obtained at 55° C., but incubation at 63° C. will indicate their presence in any number. The ratio of the 55° count to that at 63° may, it is true, be as high as ten in the case of raw milk, but pasteurised milk contaminated with thermophiles generally results in counts as high at 63° as at 55°.

(6) The majority (78 per cent.) of the raw milk samples failed to show any colonies on milk agar incubated at 63° C. Counts over 100 per ml. were very rare.

(7) Half the samples of efficiently pasteurised milk contained a few thermophiles; but rarely did the plate count exceed 100 per ml.

(8) Faulty methods of pasteurisation led to the development of a large number of thermophiles; an average of approximately 50,000 colonies per ml. being obtained at 63°.

(9) All the faulty pasteurised samples reduced methylene blue in twenty-four hours at 63°, whereas only 7 per cent. of the raw milk samples did so.

(10) All the samples of faulty pasteurised milk held for forty-eight hours at 63° produced a vigorous fermentation, generally marked peptonisation though a few cases of acid clot were observed. Only 24 per cent. of the raw milk samples were fermented.

(11) Characteristic thermophilic rods were detected in all the contaminated pasteurised samples and in 30 per cent. of the raw samples, after incubation at 63°.

(13) Thermophiles were detected in most of the samples of raw milk produced under unhygienic conditions, but only in 8 per cent. of the clean raw milk samples.

(14) Thermophilic bacteria were isolated from hay, straw silage, bran and cow manure.

(15) The routine testing of pasteurised milk for the presence

of large numbers of thermophilic bacteria can usefully be employed in advisory or control laboratories as an indication of the efficiency of the process of low temperature pasteurisation.

(16) A brief desciption is given of the morphology and cultural characteristics of some thermophiles isolated from raw and pasteurised milk. A few cultures produced acidity slowly in litmus milk at 37°, but no cultures fermenting milk at 22° were studied.

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THE COMPARATIVE VALUES OF THE COLONY COUNT ON MILK AGAR, THE COLIFORM TEST AND THE METHYLENE BLUE REDUCTASE TEST FOR THE GRADING OF RAW MILK.

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Wilson (1935) in a report on bacteriological methods for the grading of milk advocates the use of a slightly modified methylene blue test at 37° C. in preference to the colony count and the coliform test. This recommendation was based on the results of comparative tests carried out on 360 composite samples of

morning and evening's milk taken during five months at a large collecting station at Buckingham. Malcolm and Leitch (1936) examined 10,000 samples of milk of farm and factory origin over a period of twelve months, with a view to determine the degree of correlation between the modified reductase test and the plate count and coliform test. The results of their investigation led them to conclude that the reductase test is unreliable under certain conditions during cold winter weather. Nichols and Edwards (1936) have also compared the values of the plate count and modified methylene blue test. They examined 873 samples of milk taken direct from farms or from individual churns as received at a creamery. They found that the methylene blue test results gave reasonable agreement with those obtained by the plate count, and that for the general grading of milk, the methylene blue test appears to have outstanding advantages over the plate count.

The official methods prescribed by the Ministry of Health (London) in Memorandum 139/Foods (1937), issued in connection with the Milk (Special Designations) Order 1936, though

TABLE I.

Frequency Table.
Summer Samples.
(May to October).

	Log.	0—0.5	0.5—1.0	1.0—1.5	1.5—2.0	2.0—2.5	2.5—3.0	3.0—3.5	3.5—4.0	4.0—4.5	4.5—5.0	5.0—5.5	5.5—6.0	Over 6.0	
Reduction Time (Hours).	Bacterial Count.	0—3	3—10	10—31	31—100	100—316	316—1 000	1,000—3,162	3,162—10,000	10 000—31,620	31 620—100,000	100,000—316,200	316,200—1,000,000	Over 1,000,000	Total Samples.
½											1	5	22	17	45
1											1	2	10	4	17
1½											—	4	7	1	12
2									1		1	1	12	2	17
2½											—	2	1		3
3											2	—	5		7
3½											2	12	2		16
4											4	7	3		14
4½								1	2	4	6	4	3		20
5								1	1	—	1	7	2		12
5½								—	4	5	1	5	3		18
6								2	5	4	4	4	1		20
6½								3	5	1	8	4	1		22
7							5	6	7	8	4	4	1		36
Over 7					1	4	8	41	31	20	16	13	8		42
TOTAL SAMPLES .					1	4	13	54	56	42	51	74	81	24	400

TABLE II.

Frequency Table.

Winter Samples.

(November to April).

Log.		0—0.5	0.5—1.0	1.0—1.5	1.5—2.0	2.0—2.5	2.5—3.0	3.0—3.5	3.5—4.0	4.0—4.5	4.5—5.0	5.0—5.5	5.5—6.0	Over 6.0	
Reduction time (Hours).	Bacterial Count.	0—3	3—10	10—31	31—100	100—316	316—1,000	1,000—3,162	3,162—10,000	10,000—31,620	31,620—100,000	100,000—316,200	316,200—1,000,000	Over 1,000,000	Total Samples.
½													5	—	5
1											2	1	1	1	5
1½											—	—	3	—	3
2											—	1	2	—	3
2½											1	1	1	1	4
3											1	1	2	1	5
3½											1	1	1	—	3
4								1	—	2	4	1	6	1	15
4½								—	1	—	1	4	1	—	7
5								—	—	1		3	—	—	4
5½								1	2	—	3	3	3	—	12
6								1	—	1	2	1	4	—	9
6½							1	1	—	—	3	1	2	—	8
7							—	1	3	4	4	—	2	—	8
Over 7						2	40	92	51	41	35	23	19	—	303
TOTAL SAMPLES ..						2	41	97	57	49	57	41	52	4	400

retaining the plate count for the examination of pasteurised milk, recommends the use of the modified methylene blue test associated with the coliform test for the examination of Tuberculin Tested and Accredited Milk.

With the view to determine the degree of correlation between these three tests under the conditions existing in Mid- and South Wales, 800 random samples of Tuberculin Tested, Accredited and ungraded raw milk were examined over a period of twelve months.

Technique Used.

The reductase test was carried out according to the technique recommended by Wilson (1935) and the milk agar plate count and the coliform test as recommended in Bulletin No. 46 of the Ministry of Agriculture (1934).

Results Obtained.

The detailed results of the plate counts and reduction times recorded according to frequency distribution (Tables I and II)

show a fair amount of general correlation, but marked discrepancies do occur. The difference in hygienic quality of the summer and winter samples is well demonstrated; 75 per cent. of the samples during the latter period not being reduced in seven hours, whereas only 10 per cent. of the summer samples attained this standard. Similarly, the plate count results show that 50 per cent. of the summer samples and only 25 per cent. of the winter samples exceeded 100,000 per ml.

The correlation coefficient for the summer series is fairly high (Table III), but is not so remarkably high as that obtained by Wilson (1935), who gave a figure for " r " of —0.823. The results of the winter series show a much lower correlation. This is in agreement with winter results obtained by Malcolm and Leitch (1936). Wilson (1935), however, records correlation coefficients of —0.708 and —0.632 for series examined during autumn and spring respectively, but it is important to note that his investigation does not include results for the cold weather period (December—March).

TABLE III.

Correlation coefficient (r) for methylene blue reductase test and logarithm of plate count, with regression equations.

		r.	*Standard Error.*
Series I	400 Summer Samples	—0.668	0.028
Series II	400 Winter Samples	—0.437	0.046

Regression equations.

Where x = logarithm of plate count and
y = time in hours to reduce methylene blue.

Regression Equations.	*Value of y when x = log. 5.30 i.e., 200 000 per ml.*	*Value of x when y = 5 hours.*	
	Hours.	*Log.*	*Count per ml.*
Summer Samples.			
x = 5.70 — 0.20y		4.70	50,000
y = 13.62 — 1.79x	4.13		
Winter Samples.			
x = 7.23 — 0.43y.		5.08	120,000
y = 10.39 — 0.78x.	6.26		

A comparison of bacteriological grading according to the methylene blue test on the one hand and to the combined plate count and coliform test on the other, shows significant discrepancies. (Tables IV, V, Charts I and II).

CHART I.

Summer Samples.

Frequency Distribution—Methylene Blue Test and Combined Plate Count and Coliform Test.

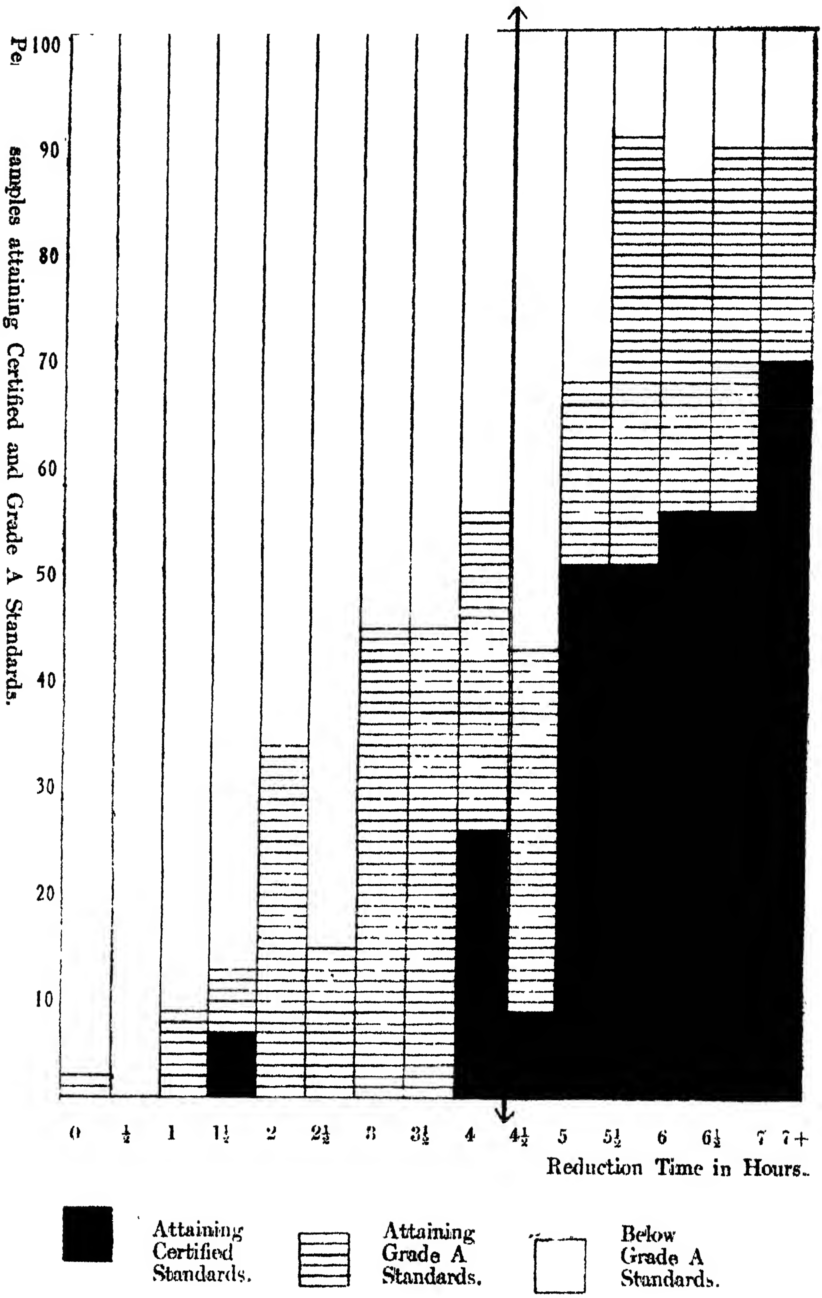

CHART II.

Winter Samples.

Frequency Distribution—Methylene Blue Test and Combined Plate Count and Coliform Test.

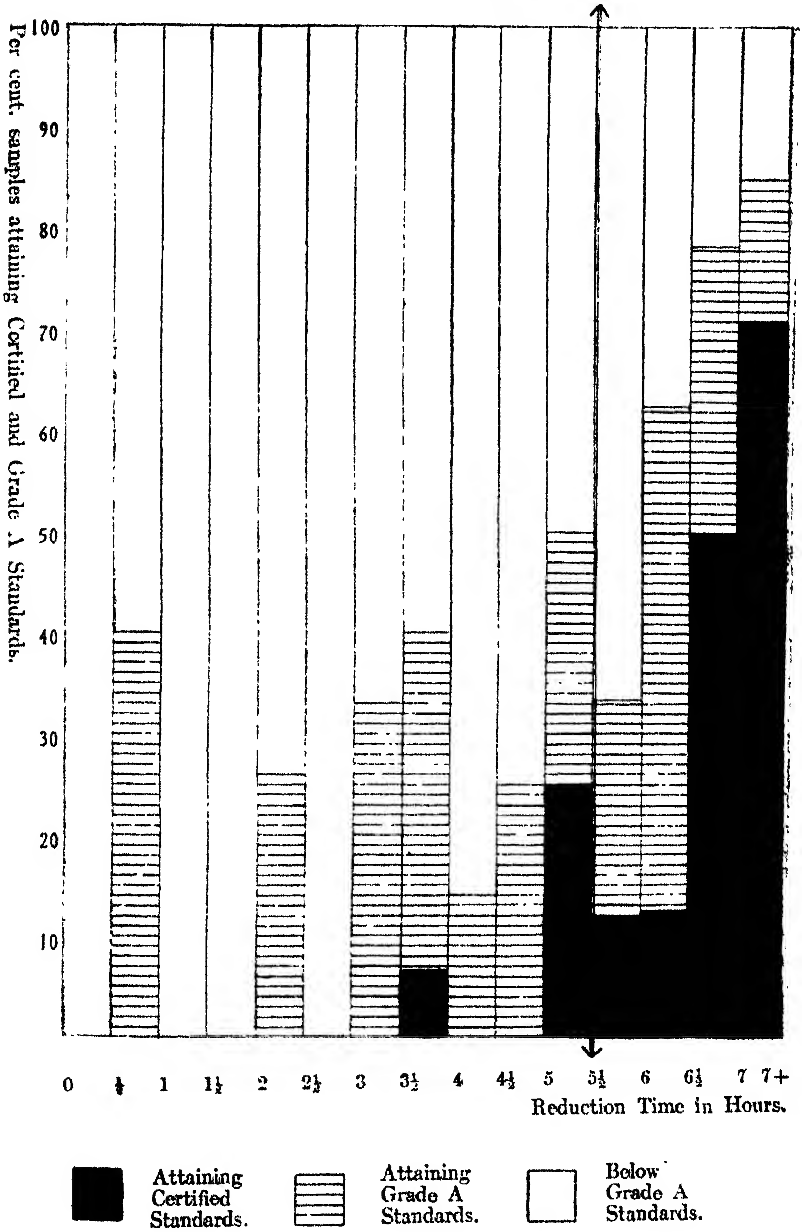

TABLE IV.

Reduction times of samples grouped according to grades obtained by Plate Count and Coliform Test.
Summer Samples.

Grade.	*Bacterial Count.*	*Coliform Organisms.*	*Reduction Time.* 0—4½ *hours. Below Methylene Blue Standard.*	*Reduction Time.* 4½ + *hours. Attaining Methylene Blue Standard.*	*Total Samples.*
Certified	< 30,000 per ml.	Absent in 1/10 ml.	6.	149.	155.
Grade A.	< 200,000 per ml.	Absent in 1/100 ml.	24.	62.	86
Below Grade A. ..	> 200,000 per ml.	Present in 1/100 ml.	121	38.	159.
Total Samples			151	249.	400.

It will be seen that 155 of the summer samples attained Certified Standards, but six of these (4 per cent.) failed to pass the Accredited Standard according to the methylene blue test. In the case of the winter series, 225 samples attained Certified Standards, of which four, (2 per cent.), failed to pass the methylene blue test.

Of the 241 Grade A summer samples, thirty (8 per cent.). failed to pass the methylene blue test, and of 295 Grade A winter samples eighteen, (6 per cent.), reduced methylene blue in 5½ hours.

TABLE V.

Reduction times of samples grouped according to grades obtained by Plate Count and Coliform Test.
Winter Samples.

Grade.	*Bacterial Count.*	*Coliform Organisms.*	*Reduction Time.* 0—5½ *hours. Below Methylene Blue Standard.*	*Reduction Time.* 5½ + *hours. Attaining Methylene Blue Standard.*	*Total Samples.*
Certified	< 30,000 per ml.	Absent in 1/10 ml.	4.	221.	225.
Grade A...........	< 200,000 per ml.	Absent in 1/100 ml.	14.	56.	70.
Below Grade A. ...	> 200,000 per ml.	Present in 1/100 ml.	48.	57.	105.
Total Samples			66.	334.	400.

A much higher lack of correlation is observed when a comparison is made of the number of samples failing to attain Grade A standards by the plate count and coliform test with the number failing to pass the methylene blue test.

Of 159 summer samples which failed to reach Grade A standards, 121 (86 per cent.) failed to pass the methylene blue test, while of 105 winter samples below the Grade A standards only forty-eight (46 per cent.), failed to pass the methylene blue test. This confirms Malcolm and Leitch's results for the cold weather period. They found that of 672 samples failing to conform to the Grade A bacteriological standards during November-February, only 277 (41.2 per cent.) failed to pass the reductase test.

TABLE VI.

Samples with colony counts over 400,000 per ml., passing the methylene blue test standards.

Period.	*Total Number of Samples.*	*Number of Samples with Colony Counts over 400,000 per ml.*	*Samples passing Methylene Blue Test Standards:— 5½ hours Winter and 4½ hours Summer*	
			Number.	*Per cent.*
Summer (May-Oct.)	400	88	6	6.8
Winter (Nov.-Apr.)	400	36	14	38.9

TABLE VII.

Percentage samples attaining Accredited Standards according to different tests.

Tests.	*Summer Samples.*	*Winter Samples.*
Colony count on Milk agar and Coliform Test	60.25	73.75
Colony count alone	61.00	78.75
Coliform Test alone	74.25	86.25
Modified Methylene Blue Reductase Test	62.25	83.50
Methylene Blue Test combined with Coliform Test	57.00	76.75

A further examination of samples with plate counts exceeding 400,000 per ml. and thus definitely of very poor hygienic quality shows that many (39 per cent.) of the winter samples and some (7 per cent.) of the summer samples were satisfactory when examined by the methylene blue test (Table VI).

A general comparison of the samples attaining Grade A or Accredited Standards according to the different tests (Table VII) also shows that the modified methylene blue test is much more lenient, particularly during winter, than the combined plate count and coliform test. Using the coliform test in conjunction with the methylene blue test, however, serves to retain a bacteriological standard for Accredited milk comparable with that prescribed for Grade A milk.

Summary.

A comparison of the results obtained during the examination of 400 summer samples and 400 winter samples of raw milk by means of the colony count on milk agar, the coliform test and the modified methylene blue test shows that :—

(1) The correlation coefficient for methylene blue reduction and the logarithm of the plate count obtained for the summer series is fairly high (—0.668), but much lower for the winter series (—0.437).

(2) Of the number of samples that attained Grade A Standards according to the combined plate count and coliform test, 8 per cent. failed to pass the methylene blue test in summer and 6 per cent. in winter. Of the samples attaining Certified Standards 4 per cent. failed to pass the methylene blue test in summer and 2 per cent. in winter.

(3) On the other hand, only 86 per cent. of the samples which failed to attain Grade A Standards failed to pass the methylene blue test in summer and only 46 per cent. in winter. Thus the two systems of grading show very little agreement during the winter period.

(4) A large proportion (39 per cent.) of the samples with very high colony counts (over 400,000 per ml.) satisfied the methylene blue test during winter.

(5) The modified methylene blue test used alone is a much more lenient method of grading milk supplies than the combined plate count and coliform test. When the coliform test is used in conjunction with the methylene blue test, however, the standard set is very similar to that of the combined colony count and coliform test as used in this country previous to 1937.

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PRELIMINARY TESTS WITH SLATE-DUST FOR THE CONTROL OF FLEABEETLES.

By the late W. MALDWYN DAVIES, B.Sc., PH.D.,
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The Turnip Fleabeetles (*Phyllotreta* spp) rank among the major insect pests of agricultural crops in North Wales. Each year, when there is a dry spell of weather during the middle or in late May, the young swede or turnip seedlings suffer considerably from the shot-hole damage caused by the feeding of the fleabeetles, often better known, though wrongly described, as the turnip fly. Re-sowing is often necessary in many districts. Owing to the fact that the adult beetles hibernate in the hedgerows and among decaying refuse it is probable that the mild winters in North Wales, and particularly in South Caernarvonshire, account for the occurrence of considerable numbers on the root fields as soon as, and sometimes even before, the swede seedlings break through the soil. Records of attacks since 1928 show that in the seasons 1928, 1929, 1930 and 1934 damage by fleabeetles was considerable and widespread throughout the province. In 1931, 1932, 1933 and 1935 the attacks were below normal, whereas in 1936 the severity of the attack varied considerably in different districts, largely owing to the frequency of local heavy thunder showers.

In May, 1935, experiments were carried out at the College Farm near Bangor to control fleabeetle attack by means of seed treatment before sowing. A wide range of chemicals possessing strong repellent odours were first tested in the laboratory to sort out those chemicals which had no harmful effect upon germination. The chemicals which did not affect germination were Oil of Wintergreen (undiluted), 5 per cent. Pine Tar Oil, 2½ per cent. Cedar Wood Oil, Paraffin (undiluted), and Orthodichlorbenzene (undiluted). Two pounds of swede seed were soaked in the separate solutions for twenty minutes and then exposed in thin layers to dry for three hours. The treated seed was sown in

duplicate plots alternating with plots sown with untreated seed. Slight rain followed the appearance of the seedlings above ground but whereas it was sufficient to prevent a severe infestation of fleabeetles it did not completely stop their appearance on the swede field. Examination of the plots at intervals revealed no evidence that the seed treatment had been successful. In each series, over 75 per cent. of the seedlings were attacked by fleabeetles and there was no difference between the attack on the treated and the untreated plots.

The soaking of the seed in Orthodichlorbenzene was tried by several farmers in the district and here, also, there was no indication that the treatment had been successful.

Owing to the failure of the seed treatment experiments were commenced to test the efficiency of dusting as a practical means of control. Petherbridge and Thomas (2 and 3) had shown that dusting with light Derris powder, at a cost of £4 10s. 0d. per acre for the four applications, was effective for the control of fleabeetles on seed-beds of brassicae. Miles (1) had shown, also, that a Napthalene-silica dust provided an effective control on a field scale at the cost of 17s. per acre for the single application.

Since the control of fleabeetles by the application of insecticides on a field scale is limited by the cost of the materials, it was desirable to compare the physical effect of covering the seedlings with a fine powder with the control obtained by dusting with insecticides. Slate dust, which is a waste product in the slate industry, is particularly cheap; when ground and airfloated so that it passes through a 250 mesh to the square inch it only costs 2s. 8d. per cwt. and the next grade, which is 100 mesh and still very fine, costs 1s. 8d. per cwt. When, in 1935, a start was made to dust the plots with the two grades of slate-dust and the insecticides, heavy rain fell as soon as the slate-dust plots were completed and, unfortunately, it proved impossible to complete the trials. However, the protection given to the swede seedlings on the slate-dust plots and the adherence of the dust to the leaves for a fortnight, warranted the continuance of the tests in 1936.

Comparative trials were, therefore, arranged for 1936, when the following materials were tested :—

1. Slate dust (250 mesh, air floated).
2. Slate dust (100 mesh).
3. Derris Powder.
4. Four parts slate dust (100 mesh), one part Derris Powder.
5. Naphthalene (Grade 16).
6. Four parts slate dust (100 mesh), one part Naphthalene.
7. 5 lbs. slate dust, plus one fluid oz. Orthodichlorbenzene.

The dusts were applied by means of a rotary dusting machine, similar to that commonly available now for use in fumigation of rabbit warrens. Slate-dust is a particularly fine dust and gives an excellent covering to the seedling swede; on moist leaves the dust spreads over the leaf in a thin film which adheres very efficiently. The finer grade (250 mesh) tended to clog in the machine used, and since it was no more efficient than the 100 mesh in covering the leaves and the cost was almost twice as much, the latter grade was used to dilute the insecticides. The plots were each 100 yards long and seven drills wide; the treated plots alternated with the untreated, and the series was duplicated.

Counts of the number of damaged plants were taken at three day intervals and it was intended to give these counts together with the resulting number of plants on each plot. But, unfortunately, about the twelfth day after dusting a flock of wild pigeons commenced to feed on the swede seedlings in this particular field, and it was apparent that they selected the larger foliage of the treated plots, so that before they were satisfactorily scared off they had done sufficient damage to prevent the presentation of the final results of the trials. Since, however, the counts taken on the tenth day after dusting, May 23rd, give an indication of the degree of protection given to the seedlings these are given in Table I.

TABLE I.

Comparative tests of dusting swede seedlings.

Plots.	*Rate per acre.*	*Approx. cost per acre.*	*Percentage damaged seedlings.**	
			Treated.	*Untreated.*
Slate-dust (250 mesh)	1 cwt.	2/8	10	79
Slate-dust (100 mesh)	1 cwt.	1/8	2	83
Derris Powder	¾ cwt.	£9/0/0	15	81
Slate-dust (4), Derris (1)	1 cwt.	£2/5/0	8	74
Naphthalene (Grade 16)	1 cwt.	£1/12/0	30	76
Slate-dust (4), Naphthalene (1)	1 cwt.	8/-	7	89
Slate-dust plus 1 fluid oz. Orthodichlorbenzene per 5 lb.	1 cwt.	2/-	6	88

* The 100 plants were counted by taking four random strips of twenty-five plants each in each plot.

The infestation of fleabeetles on the root fields at the College Farm was not as severe as anticipated but the percentage of damaged seedlings on the untreated plots was high although the

damage was not exceptionally severe. The undamaged foliage of the treated plots stood out in contrast. A comparison of the differently treated plots showed that the slate dusts had given as good a protection as the insecticides whether the latter were applied either alone or incorporated with slate-dust. In fact the higher percentage of leaf damage on the derris powder and naphthalene plot was due to the fact that in both these cases there was poor adherance to the leaves although there was ample insecticide on the soil around.

A similar series of tests was carried out at Madryn Farm School, South Caernarvonshire, where the attack was in progress when the dusts were applied, and considerable numbers of flea-beetles were on the seedlings. The plants were dusted on May 20th, but heavy rain fell during the night and continued the following day. The plots were re-dusted on May 25th but again heavy rain fell at night and on subsequent days It was apparent on June 3rd, following a dry period, that the dusting in all cases was not effective under these exceptional conditions for the flea-beetles had returned to the plants equally on all plots. The writer is indebted to Mr. Evan Davies, M.Sc., Assistant Agricultural Organiser for Caernarvonshire, for assistance given at this centre. Slate-dust (100 mesh) was tested by Mr. A. O. Williams, B.Sc., Assistant Agricultural Organiser for Anglesey, at several centres in that county and he reports that the results were very satisfactory.

It is, therefore, proposed to continue the tests during 1937 with a view to ascertaining the relative efficiency of this cheap and very fine slate-dust under drier conditions when attacks are usually more severe.

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POISONING BY RAGWORT.

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Mortality in cattle from any obscure cause is, more often than not, attributed by the owner to plant poisoning. This theory however, has frequently proved to be erroneous on investigation, the actual cause of trouble being found to be either bacterial, chemical or parasitic.

Diagnosis of plant poisoning is, as a matter of fact, by no means simple. A large number of poisonous plants induce very similar symptoms, and the post-mortem appearances are also much alike. The evidence in the majority of cases of plant poisoning in animals is, therefore, unavoidably circumstantial, depending on the history of access to the plants, and the finding of portions of them in the ingesta. In the case of poisoning by ragwort, however, the experience of the writers has confirmed them in their opinion that history, symptoms and post-mortem appearances are quite typical and characteristic.

Mortality in South Wales.

Outbreaks of poisoning by this plant have been observed in the counties of Glamorgan, Monmouth and Pembroke. In every instance the plant was fed in hay, and evidence of grazing of fresh plants was not observed. In the Monmouthshire case the plant did not exist on the farm.

The first case investigated by the writers occurred in February, 1929, in connection with the deaths of four cattle in Glamorgan. The animals had been seen during illness by a veterinary surgeon who had also examined one of them post-mortem. He reported to the Department that he suspected plant poisoning, but stated that the animals had been indoors for some months. One of the writers then made a survey of the farm and on enquiry found that in November and December, hay from a particular field had been fed. An examination of the stack in question showed that almost half the herbage consisted of ragwort. The hay had not been fed to the cattle for about six weeks. Ragwort was then suspected definitely to be the cause of the illness and death of the animals.

Another outbreak occurred in July, 1936, where seven cattle had died on a farm in Monmouthshire. The veterinary surgeon who had been called in suspected plant poisoning. The farm had

been examined without revealing any definite evidences of a poisonous weed except bracken and yew. The contents of the stomach of one of the animals were then examined, but no poisonous plant was found. One of the writers was then asked to look over the farm. There was no evidence that the bracken had been eaten, and the history of the deaths did not agree with yew poisoning. The cattle had been out on the pastures since May, but illness did not appear until about six weeks afterwards. One animal which was ailing at the time of the visit showed considerable emaciation and yellowing of the skin, which was particularly noticeable around the eyes and muzzle. Staggering gait and diarrhoea with severe straining were also noticed. Ragwort poisoning was suspected, but an examination of the hay fields did not reveal any traces of it, nor indeed, of any other poisonous plant. However, just after the farm had been completely surveyed, the owner mentioned that he had purchased hay from a field about a mile away, and this hay had been fed during April when food was extremely scarce on the farm. An examination of the field from which the hay had been bought showed an abundance of ragwort.

Perhaps the most striking instance, however, is the outbreak which occurred in Pembrokeshire in 1936. Eighteen cattle were reported to have died between the beginning of May and the end of September, but the advice of the Department was not sought until the beginning of October, when a dead animal was examined. The symptoms described by the owner and his veterinary surgeon were, in order of appearance, unsteadiness of the hind legs, diarrhoea, a peculiar " heaving " movement of the abdomen leading to excessively severe straining which occasionally resulted in eversion of the rectum. Death followed symptoms of delirium and resulted in about four days from the commencement of straining. From previous experience a tentative diagnosis of ragwort poisoning was made, and this was fully confirmed by a post-mortem examination and the history of the case.

Post-Mortem Appearances.

It is proposed to give a somewhat detailed description of the post-mortem appearances in respect of this particular case as they epitomize the typical characteristics referred to above. The skin of the whole carcase was abnormally yellow. The rectum had apparently been everted at one time. The abdominal cavity contained a considerable quantity of blood-stained fluid. The liver was reduced in size, with markedly rounded edges. It was

yellowish-pink in colour and extremely hard or "cirrhotic"—in fact, it was difficult to cut it with a knife. The gall bladder was greatly enlarged and contained fully 38 oz., *i.e.*, almost one quart, of dark, viscid, bile. Rumen, reticulum and omasum (*i.e.*, the first three stomachs) were apparently quite normal both externally and internally. No portions of ragwort could be found in the contents of any of the stomachs. On the surface of the abomasum (fourth stomach) small haemorrhages were noticed. On opening this organ, similar haemorrhages were observed on the lining, which was thickened to the extent of approximately three-eighths of an inch. The thickening was actually due to a gelatinous exudate under the stomach lining. Haemorrhages were also present on the external surface of the small intestine, the lining of which showed a diffuse inflammation. The last portion of the large intestine was acutely congested, with haemorrhage in the rectum. The kidneys were pale and somewhat soft. The spleen was normal. The contents of the chest cavity were normal, except that there was a quantity of fluid present in the pericardial (heart) sac.

Ragwort was present in the fields but not in exceptional quantity. The pasturage was poor and the owner mentioned that this had perforce been supplemented by hay from a certain stack which was found to contain quite 10 per cent. of ragwort. The owner reported that deaths commenced about a month after the hay from the stack had been fed, but stated that its use had been discontinued for nearly five months.

"Latent Period."

This factor of the "latent period" in ragwort poisoning is a most peculiar, and at the same time, a most puzzling circumstance. It is probably the chief difficulty encountered in persuading the farmer that his cattle have actually died from poisoning by ragwort, because by the time deaths commence he has probably forgotten that ragwort had ever been fed, if indeed, he ever connected the plant with the mortality. Symptoms may not appear while the animal is actually being fed on hay containing ragwort, but may be observed only after a period of some weeks or even months. This "latent period" is given by various authorities as from three weeks to about three months. What factor suddenly sets up symptoms of poisoning after that time is not known and there is room for a considerable amount of research on the subject. There is no doubt, however, that the poison is cumulative and that it affects the liver to a marked degree.

In the case of the first two outbreaks above mentioned, the "latent period" was four to eight weeks, but, in the case of the Pembrokeshire outbreak it was almost five months before some of the animals showed visible symptoms. In this connection the resistance of the individual animal must be taken into consideration. It does not follow that because a number of animals all feed on ragwort at the same time, they will all show symptoms of poisoning at the same time.

With regard to the post-mortem appearances already mentioned, the large quantity of bile in the gall bladder, the yellow and cirrhotic liver and the thickened lining of the fourth stomach are considered by the authors to be quite typical of ragwort poisoning. The history, the characteristic type of straining and the excessively jaundiced appearance of the skin during life confirm the diagnosis.

Unfortunately, no experimental treatment has proved to be of any avail in curing animals which show symptoms of ragwort poisoning.

The Control of Ragwort.

It has been said that sheep are not affected by ragwort and that they could be employed in order to eat down the plant on infested farms. It has been found experimentally, however, that sheep *can* be killed by the plant but they certainly do not appear to be so susceptible as cattle. This is probably largely due to the fact that they graze the plant when it is very young and before it has attained its full quota of poison, whereas at the time it is cut in hay, just before flowering, its poison content is at its maximum.

The caterpillar of the Cinnabar Moth feeds on the leaves of the ragwort and a seed-fly eats the young seeds. However, these agents do not completely destroy the plant which is able to produce sufficient seed to give rise to a new crop. The moth has been seen in enormous numbers on ragwort in the coastal areas, and on groundsel in gardens in Glamorgan. It appears therefore that great hopes cannot be entertained of controlling the weed by this moth in this country.

In all the cases investigated the ragwort occurred on fields, the manuring and general management of which had been neglected. It is under these conditions that ragwort proves a scourge. In the Glamorgan case mentioned, the hay crop was the first taken after grazing for a number of years. The field was a long way from the farm and this made it difficult to manure and no measures had been taken to control the plant. The

history of the Monmouthshire field was only known for two seasons, but it is probable that the hay which was fed was mown for the first time after a number of years in pasture. The best method which can be recommended for the eradication of the weed is pulling up or cutting the plants before they form seeds, and this operation should be repeated for at least two successive years. If grassland is well manured and the grazing well controlled, ragwort should not be abundant as it is not particularly able to compete with grass. On a certain farm in Pembrokeshire ragwort had been " so luxuriant that cattle could hardly be seen when lying down." The farmer got rid of it in three years by pulling up by the roots, dressing the field with basic slag and grazing by sheep in early spring. This completely destroyed the ragwort and the field has been an excellent pasture ever since. It is probable that a dressing of about 1 cwt. of sulphate of ammonia applied while the dew is on and followed by a fine day, would both tend to injure the ragwort and stimulate the grasses. Both basic slag and the hard grazing, together with the light treading of the sheep, encourage the small clovers which in turn fertilize the land. Hay should not be made from a badly infested field as this is exceedingly dangerous.

The plant generally dies down completely after it has once flowered. It can be destroyed by spraying with a solution of 1 lb. of sodium chlorate in 10 gallons of water.

In parts of Glamorgan and elsewhere, ragwort is often called " tansy." However, the two plants can be readily distinguished as the leaves of ragwort are somewhat similar to those of the chrysanthemum while the leaves of the tansy are more divided, resembling those of the ash. The flowers on ragwort are larger and brighter yellow in colour than those of the tansy which are like small brown buttons.

ABSTRACTS, REVIEWS, AND BIBLIOGRAPHICAL NOTES.

ANIMAL NUTRITION.

Abstractor:

R. O. Davies, M.Sc., University College, Aberystwyth.

Artificially Dried Grass; The Nutritive Value of—and the Effect on the Quality of Milk Produced by Cows of the Main Dairy Breeds

S. J. Watson and W. S. Ferguson. *J. Agr. Sci.* (1936), 26, 189-209.

An experiment was carried out with two groups of ten cows each for a period of twenty weeks to find the effect of replacing a proportion of the concentrates in a normal winter ration with artificially dried grass. The response to carotene in the dried grass as shown by the butter colour was quite obvious. The cows also appeared to do better on the ration including dried grass which showed a significant advantage over the ordinary winter ration in respect of weight increases.

R.O.D.

Artificially Dried Grass; The Value of—Silage made with added Molasses and A.I.V. Fodder in the Diet of the Dairy Cow and their Effect on the Quality of the Milk, with special reference to the Value of the Non-protein Nitrogen

S. J. Watson and W. S. Ferguson. *J. Agr. Sci.* (1936), 26, 337-67.

An experiment was carried out with twenty cows for seventeen weeks to test the effect of dried grass and silage on the yield and quality of the milk. Approximately 8 lb. of dried grass and 30 lb. of molassed silage or A.I.V. fodder were fed per head daily. The above ingredients raised the Vitamin A potency of the milk to a level similar to that of the average of the grazing season for pasture-fed cows. For some reason not capable of explanation the A.I.V. fodder was not so efficient as the other two foodstuffs. The experiment indicates that the products of protein degradation in silage have a high biological value.

R.O.D.

Bacon Pig; The Nutrition of the

H. E. Woodman, R. E. Evans, E. H. Callow, J. Wishart. *J. Agr. Sci.* (1936), 26, 546-619.

It is shown that a feeding treatment providing 12 per cent. of fish meal from weaning to 90 lb. L.W., 10 per cent. of fish meal from 90 to 150 lb. and 5 per cent. of a mixture of equal parts of meat meal and ex. soya-bean meal in the final period supplied all the digestible protein required by Large White bacon pigs for the maximum rate of growth permitted by the net energy content of the ration.

It appears that feeding the pigs individually proved effective in getting the animals ready for the bacon factory at a distinctly earlier date than those fed in groups, without any loss in efficiency of meal conversion over the period of trial. Over a L. W. increment of 151 lb. the individual feeding led to an average saving of 40 lb. of meal per head, *i.e.*, 7.2 per cent. of the average meal consumption per head of the group fed animals.

Statistical analysis demonstrates a slight yet significant difference in the rate of L.W.I. in favour of the gilts. Over the whole period of feeding, the gilts required on an average a smaller amount of meal per lb. L.W.I. than the hogs. R.O.D.

Calf Feeding; The relative Values of Raw and Pasteurised Milks in

A. C. McCandlish, A. N. Black. *West Scotland Agri. Coll. Milk Prod. Dept. Res. Bull.*

A comprehensive review of the results of feeding experiments, and laboratory investigations. In experiments reported the calves on pasteurised milk made slightly less live weight gains than those on the raw milk. In all groups disease was more frequent among the calves on pasteurised milk than among those on raw milk. The raw milk calves had also better coats. R.O.D.

Calf; Mineral Metabolism in the—and the Addition of Inorganic Minerals to the Calf's Diet.

E. J. Sheey, B. J. Senior. *J. Dept. Agr. I.F.S.* (1936), 1-32.

The results of group and balance experiments dealing with mineral metabolism in calves past the age of seven weeks are reported. The following conclusions were arrived at: (1) When the fodder is of low quality and the remainder of the diet consists of cereals or their by-products, roots and oil cakes, it is beneficial to raise the sodium chloride content of the ration by feeding common salt at the rate of 1 per cent. of the meals consumed. (2) When the Calcium (CaO) to phosphorus (P_2O_5) ratio of the diet is less than unity the addition of calcium to the ration not only supplies a calcium deficiency, but also, by correcting the balance, raises the retention of phosphorus. (3) Calves which are given a diet of fodder, cereals, roots and oil cake, and fed very liberally on meals, suffer from an insufficiency of calcium because of the necessarily low proportion of fodder consumed, and it is suggested that this is not a rare occurrence. (4) When no other calcium-rich food is fed, and the rate of consumption even of good quality hay is less than what would correspond with four pounds at five months of age, it is of advantage to supplement the diet with either sterilised bone flour or ground limestone. The inclusion in the daily ration of half a gallon of milk per calf, or the incorporation into the meal mixture of 15 per cent. of meat or fish meal obviates the necessity for a calcium supplement. (5) The addition of cod liver oil to a diet which includes poor quality weathered hay raises the digestibility of the dry matter of the entire ration. Calves fed a satisfactory ration, and treated in the manner customary on the ordinary farm, do not benefit from cod liver oil.

R.O.D.

Calcium and Phosphorus Metabolism; The effects on—in Dairy Cows, of feeding low Calcium Rations for long periods.

E. B. Meigs, W. A. Turner, E. A. Kane, L. A. Skinn. *J. Agr. Res.* (1935), 51, 1-26.

It is found from these experiments that the percentage of Ca and P. in the fat free bodies of mature, normal cows and the Ca : P ratio both in the whole body and the bone are remarkably constant. These relationships are altered much less than is generally considered to be

the case when cows are kept on low Ca rations for long periods. The percentage Ca assimilation for cows fed on a low Ca ration consisting of timothy hay was of the order of 50 per cent. It is suggested that the failures in reproduction which have occurred on rations in which the roughage was timothy hay or straw are to be attributed to a vitamin A deficiency rather than to a Ca deficiency. R.O.D.

Digestibility Trials; Technique of—with Sheep and its application to Rabbits.

S. J. WATSON and E. A. HORTON. *Empire J. Expt. Agr.* (1936), 4, 25-35.

The comparison of rabbits with sheep as instruments for determining digestibility has shown agreement only in the values for protein. The rabbit does not digest fibre as efficiently as does the sheep, and values obtained with the former cannot be applied to the latter animal.

R.O.D.

Feeding; Scientific Rules for—

V. STANG. *Proc. 12th Internat. Vet. Congr. New York* (1935), Vol. 3, 503-520. (Vet. Coll., Berlin).

The paper describes the theoretical and practical aspects of the principal feeding standards used throughout the world. It is concluded that unification of methods for calculating feed requirements of animals is not possible and that all methods and feeding standards can serve only as a general basis. It is pointed out that the hygiene as well as chemistry of feeds deserves attention.

Although sterility, especially in cattle, is often considered as being caused by faulty feeding, there is need for further investigation in collaboration with veterinarians. R.O.D.

Foals; Experimental Studies on grazing

H. NIETCH. *Landwirtsch Jahrb.* (1935), 81, 525-575. (Inst. Agric. Chem. and Bacteriol., Breslau Univ.).

Yearling colts consumed on the average 48-84 lb. of meadow grass daily, but under abnormal conditions of temperature, weather, and disturbance by insects the consumption may on occasion be well outside this range. The time required for the grass to pass completely through the digestive tract varied from 9½ to 40 hours. Consumption of drinking water fluctuated greatly, quite apart from temperature changes. The differences between individual animals were also very great, one colt in particular generally consuming about twice as much water as any of the others. R.O.D.

Grass; The Quantities of—that Dairy Cows will eat

T. E. WOODWARD. *J. Dairy Sci.* (1936), 19, 347-57.

The results of these grazing experiments indicate that the limit of a cow's capacity is about 30 to 50 lb. dry matter in grass per day, depending on the size. R.O.D.

Iodine for Brood Mares

Proc. Amer. Soc. Animal Prod. (Jan., 1935), 89-92. (Oregon State Coll.).

In the endemic goitre area in which the Oregon State College Farms are situated, it was found that the administration of 15 grains of

potassium iodide per week to mares during the last half of the gestation period prevented goitre in foals. A dose of 5 grains per week was apparently inadequate, although it was sufficient to prevent goitre in calves.
R.O.D.

Milk Production; Satisfactory—from Winter Rations without concentrates on High Moor Farms.

Mitt. Ver. Moork. Berlin (1935), 53, 3-12. (German Moor Exp. Stat., Bremen).

The experience of the Bremen Station shows that regular and abundant supplies of P and K are the chief manurial requisites of moorland herbage. Many years' trials on all kinds of moorland soil have proved the ineffectiveness of nitrogenous fertilisers. Cows fed throughout the year without concentrates on the produce of high moor soil gave an average yearly performance of 10,020 lb. milk and 304.5 lb. butter fat. Previously reported experiments on low moor showed an average milk production of 9,019 lb. milk and 299.9 lb. butter fat without the use of concentrates.
R.O.D.

Milk Production; The Mineral Requirements of: the annual cycle of mineral and nitrogen metabolism of the Milch Cow as affected by Alfalfa Hay, Timothy Hay, Bone Flour and Ground Limestone.

E. B. FORBES. *Pennsylvania State Coll. Sch. Agr. and Exp. Stat. Bull.*, No. 319 (May, 1935), pp. 152.

It is concluded from these balance studies that cattle may require mineral supplements, especially bone meal, only when the ration is abnormally poor in Ca or P., or when they receive very little roughage. In view of this, it is suggested that mineral supplements should not be incorporated in commercial mixed feeds but that they should be sold separately.
R.O.D.

Milk Production with the use of mainly Home-grown Protein.

J. SCHULTZ. *Weidew. Flutterbau Beil. deutsch landwirtsch Tierz* (1935), 10, 45-6.

Experiments conducted for several years have shown that it is possible to obtain satisfactory milk production without the use of oil cake and other imported concentrates. The basal rations consisted of meadow hay, marrow stem kale, silage of vetch mixtures, fodder beet, etc., and some lucerne hay.
R.O.D.

Mineral Metabolism; Observations on the—of Pullets. 2

R. H. COMMON. *J. Agri. Sci.* (1936), 26, 85-100

An experiment is described to provide information on ammonia excretion and on calcium-phosphorous metabolism in the laying pullet. An increased ammonia excretion was found to coincide with heavy phosphorous excretion. It is shown that heavy phosphorous excretion does not accompany egg laying provided the calcium carbonate intake is sufficiently high. Pullets on a ration containing 5 per cent. calcium carbonate laid eggs containing a higher percentage of P_2O_5 than pullets receiving a similar ration but from which the calcium carbonate supplement was omitted. Some evidence is put forward in support of the view

that current standards pitch the requirements of digestible protein for egg production at too high a level. R.O.D.

Sheep; On some physiological aspects of the Phosphorus Metabolism of the

H. R. Marston, *J. Counc. Sci. Indust. Res. Austral.* (1935), 8, 293-304.

A review is given of certain aspects of the literature together with a discussion of recent experimental work in Australia. The general conclusion reached is that the widespread use of phosphatic licks for Australian sheep is unjustified until further information is acquired. R.O.D.

Sheep; Studies in Mineral Metabolism. 33. Iodine in the Nutrition of Sheep. 2nd Report

A. I. Malan, P. G. Du Toit, J. W. Groenewald. *Onderstepoort J. Vet. Sci.* (1935), 5, 189-200.

For a period of thirty months, three groups of merino ewes were given a daily supplement of 0.002, 0.02 and 0.06 g. potassium iodide respectively, while a fourth group, receiving no potassium iodide, acted as control. There was no significant differences between the groups in weight, wool production or in reproduction. R.O.D.

Sheep; The Lime requirements of. The Limitations of our knowledge

M. C. Franklin. *N.Z. J. Agric.* (1935), 51, 257-66.

From this review of the above subject the author concludes that the exact quantitative requirements of animals for lime vary so fundamentally with the condition of the animal and the nature of its food that they are unlikely to be determined. Stress is laid on the animal's capacity for adjusting itself to a low lime intake and on the variability of lime utilisation from different dietaries. R.O.D.

Silage; Feeding Experiments on the Effect of—on Yield and Composition of Milk and Butter.

Dibbern, Sudholt, Rintelen and Schätzel. *Ztschr. Züchtung B.* (1935), 33, 409-416.

Flavour and aroma of butter were not affected by the silage, but its colour was progressively improved. Melting and solidifying points of the fat were slightly lowered, but otherwise no change in the fat constants could be detected. R.O.D.

Silage; The Stack—method of preserving Forage Crops and the comparative nutritive value of Oat and Pea Silage made in a Stack and in a tower

J. C. Knott, R. E. Hodson, R. R. Graves. *J. Dairy Science* (1935), 18, 438.

The stack silage contained 20 per cent. more moisture than the tower silage, while the chemical composition of the dry matter was similar. In tests with sheep it was found that the digestibility of the crude protein in the stack silage was 17 per cent. less than that of the tower silage, while the digestibilities of the ether extract and of the N-free extract were about the same. R.O.D.

Stock-Feeding; Some recent—Trials

W. G. R. Paterson. *Trans. Highl. and Agric. Soc. Scot.* (1936), 48, 58-81.

Feeding trials conducted at Auchincruive are reviewed. It is found that the food value of marrow stem kale per acre will often be much greater than that of swedes. These experiments indicate that sprouted maize would seem to have a marked stimulating effect in beef production and contributes to greater daily live-weight increase. Sugar-beet leaves from an average crop were found, per acre, to be approximately equivalent for sheep feeding to six ton of swedes. R.O.D.

ENTOMOLOGY.

Abstractor:

J. R. W. Jenkins, M.Sc., University College, Aberystwyth.

Aphides infecting the Potato Crop. V. Studies on; Laboratory Experiments on the Effect of Wind Velocity on the Flight of Myzus persicae Sulz.

W. M. Davies. *Ann. Appl. Biol.*, 23, No. 2 (May, 1936).

Laboratory experiments, designed to discover the effect of variation in artificially produced wind velocity on the flight of *M. persicae*, were carried out under conditions of temperature, light and humidity favourable to flight. When no wind passed through the apparatus, the test aphides averaged 154.8 flights per minute. Low wind velocities had a marked effect in reducing flight, which completely ceased when the wind reached a velocity of 3.75 m.p.h. J.R.W.J.

Cabbage Aphis, Brevicoryne brassicae L; Observations on the Life History and Control of the

F. R. Petherbridge and J. F. M. Mellor. *Ann. Appl. Biol.*, 23, No. 2 (May, 1936)

A description is given of studies which followed serious losses caused by this aphid in several of the Eastern Counties. Symptoms of attack are described and the life history quoted. Control measures should aim at preventing the migration of aphids from the old plants to newly planted ones, and for this, a nicotine and soft soap spray proved effective. Cultural methods calculated to reduce infestation are discussed. J.R.W.J.

Derris Dust; Bees and

W. J. Gerard. *Bee World*, 16, No. 11 (1935).

It is recorded that great Bee mortality followed the application of Derris dust to raspberry blossoms. Examination of dead bees showed the spiracles to be covered by the dust, and quantities of brood had apparently been killed by feeding on contaminated pollen.

J.R.W.J.

Flea Beetles; The Control of by means of a Seed Dressing

C. L. WALTON. *Rep. Agric. Hort. Res. Sta., Bristol, 1935.* (1936).

As a result of a series of experiments, the most successful dressing for the protection of Crucifers from flea beetle attack was found to consist of 4 lb. paradichlorobenzene and 1 lb. naphthalene, dissolved in 1 gal. kerosene. It is probable that unrefined kerosene (paraffin) would be equally effective as its action is mainly solvent. The proportions stated should be strictly adhered to, and the mixture should be used at from half to one fluid ounce per lb. of seed, making the maximum cost 2d. per acre. The dressing does not injure the seed, which should be treated one day before drilling. The treatment gives considerable success, and confers a high degree of protection from the germination period to the rough leaf stage. In common with other methods of seed treatment however, its efficiency appears to depend in some degree upon rapid germination, since delayed germination due to drought in 1934 considerably reduced its effectiveness. J.R.W.J.

Household Pests; Their Habits, Prevention, and Control.

P. B. COLLINS. Crown 8vo., 98 pp., 6 figs. London: Sir I. Pitman and Sons, Ltd. (1936). 2/6 net.

Gives a popular account of the bionomics, prevention, and control of the more common British indoor pests such as clothes moths, cockroaches, furniture beetles, ants, and fleas. Appendices deal with the use and cost of insecticides, and discuss the control of such household visitors as wasps and woodlice. J.R.W.J.

Woolly Aphis; A Note on the Treatment of dormant Nursery Stock against

R. M. GREENSLADE. *Rep. E. Malling Res. Sta., 1935* (1936).

Experiments were carried out to determine the optimum concentration of tar distillate dipping solutions and of hydrocyanic acid gas, for the control of woolly aphis on dormant apple rootstocks. A 10 per cent. solution of tar distillate, and 2 oz. of Sodium Cyanide per 1,000 cu. ft. are recommended. At these concentrations, satisfactory control was obtained after twenty seconds dipping, and 2½ hours fumigation respectively, and neither treatment had any deleterious effect on the stocks. J.R.W.J.

Woolly Aphis; Studies on the Resistance and Immunity of Apples to the

M. B. CRANE, R. M. GREENSLADE, A. M. MASSEE, and H. M. TYDEMAN. *J. Pomol.*, 14, No. 2 (July, 1936).

Experiments carried out between 1922 and 1935 during studies of the various aspects of woolly aphis infestation of apple trees are here described, one of the main objects being to obtain stocks which combined other desirable characters with immunity from attack. Almost four thousand seedlings have been obtained by crossing immune and non-immune varieties in the various combinations, and have been entomologically investigated, and tested for immunity. The authors are led to the tentative conclusion that immunity is a heritable character governed by the separation and re-grouping of a number of genes. A preliminary account is given of some of the immune seedlings obtained. J.R.W.J.

LIVE STOCK

Abstractors:

A. D. Buchanan Smith, M.A., B.Sc., F.R.S.E., Institute of Animal Genetics, University of Edinburgh,

AND

E. J. Roberts, M.A., B.Sc., University College, Bangor.

Crossbreeding Swine; A Six Years' Study of

L. M. Winters, O. M. Kiser, P. S. Jordan, and W. H. Peters (1935). *Minnesota Agric. Exp. Stn. Bull.*, 320.

This experiment was conducted to determine how much added vigour a farmer may expect as the result of crossing two breeds of swine. Secondly, should the crossbred gilts be marketed, or can they be used to advantage for further breeding? If the crossbred sows are better mothers, how can they best be used for further breeding?

The experiment was begun in the autumn of 1928. The foundation stock consisted of animals farrowed in the spring, of Poland-China, Duroc-Jersey, and Chester White breeds. The experiment was conducted at two places, and standard rations were used at both the Stations throughout the experiment. Detail is given of the results as regards farrowing, weaning (sixty days), and fattening records. In every respect the first crossbreeds excelled the purebreds, except in the deaths pre-weaning, and these were due to the purebred mothers. Backcrosses were made either to one of the parent breeds (backcross) or to a third breed (three-breed-cross). With the exception of the number of live pigs farrowed and total number of pigs farrowed in the backcross group, these also excelled the purebreds: but this backcross group constituted the smallest group, and there was more irregularity in the results obtained. Otherwise, the backcrosses show a decided superiority over the purebreds for market hog production.

Taken as a whole, the first cross and back cross pigs have about the same advantage over the purebreds. Where the first cross sows were mated to a boar of a third breed (three-breed-cross group) these possessed the greatest advantage by nearly every item of comparison. The three-breed-cross pigs combined the advantages of being crossbreds themselves, and of being out of crossbred sows.

Of the various items of comparison, the following are probably of most importance to the commercial pig producer :—Litter size, weight at weaning, maturity, and economy of live weight gain. As regards weight of litter at weaning time, all groups excelled the purebreds. Especially it would appear that the crossbred sows were a greater factor in promoting growth up to weaning than the fact that the young pigs were themselves crossbred. In this connection it should be remembered that pigs are carried for about 112 days before birth, and nursed for some sixty days after birth. For some 170 days, therefore, their mothers are the main factor in their environment. Consequently, if the crossing of two breeds results in sufficient increased vigour to make crossing worth while, it would appear probable that crossbred sows should, in turn, be sufficiently more vigorous to make better mothers than purebred sows. The figures obtained seem to prove this to be the case.

All three groups of pigs grew faster and reached market weight earlier than the purebreds. The backcross to one of the parent breeds possessed the greatest advantage in this respect, but again it is doubtful if this difference is significant.

Concerning economy of live weight gain, the advantage in feed saved was significantly in favour of each of the three crossbred groups. One-half bushel of corn saved per pig on each of the firstcross and backcross groups, and two-thirds of a bushel on the three-breed-cross group is worth something.

Several workers were concerned with the experiment, and their conclusions are in remarkable agreement. They agreed that all three groups of crossbreds were better market pigs than the purebreds. The crossbred sows had the appearance of being good brood sows with large udders: they were quiet and easily handled.

BREEDING.

	Purebred.	*First Cross.*	*Three-breed-cross.*	*Back Cross.*
No. of Sows	76	45	24	16
No. of Pigs	715	440	245	135
Live pigs born per litter	8.26	9.22	9.88	8.13
Birth weight of live pigs, lbs.	2.45	2.60	2.59	2.91
Weaning.				
Litter size	5.54	5.95	7.71	6.25
Litter weight per pig, lbs.	28	33	33	36
Advantage over purebreds.				
Daily live weight gain, lbs.	—	+ .12	+ .11	+ .14
Feed per 100 lbs. live weight gain ...	—	—12.68	—16.21	—12.15
Days to reach 220 lbs. live weight ...	—	—17	—17	—22

A.D.B.S.

Fat Lamb Production; Sheep Crossing Experiments Conducted at Askham Bryan, York, 1930 to 1935. Part I. Experiments with Cheviot Ewes, 1930-1934. Part II. Experiments with Masham Ewes, 1932-1935

G. C. V. Robertson. 1936. *Univ. Leeds and York. Counc. for Agric. Educ.*, No. 183. 52 pp., 16 figs.

If a further demonstration is needed of the difficulties besetting the experimenter who wishes to evaluate the relative merits of different crosses of domestic breeds of animals, it is provided in this account. Although the crossbreeding has been carried out on a fairly large scale and many interesting data have been secured, it is very difficult to draw

any definite conclusions. The work was divided into two parts, the first being concerned with Cheviot ewes and their lambs by Ryeland, Shropshire, Southdown, and Suffolk rams, and the second with Masham ewes (first cross Wensleydale × Swaledale) and their lambs by English Leicester, Oxford, Down, and Suffolk rams. About 20-25 Cheviot ewes were put to one ram of each of the four breeds for four years, so that altogether 80-90 matings were used for each cross, and from these matings data were recorded concerning number of lambs born and reared, birth weight, rate of live weight increase, age at 70 lb. weight, carcass weight, and percentage, price realised and financial return per ewe. Unfortunately all the data are given in the form of averages without estimates of the variance, so that it is impossible to tell which differences are likely to be real. The number of lambs born, for instance, was 1.5 for all crosses except the Suffolk, in which it was 1.63. If this difference were significant, it would be very interesting. The weights of the ewes at various times from mating to parturition would have had a bearing on this subject as well as on the number of lambs reared and rate of growth of survivors, but apart from evening out the groups of ewes before the mating season ewe weights appear to have been neglected. The average birth weight of the lambs (breeds in order as above) was 9.4, 9.1, 8.4 and 8.9 lb.; the average weight increase per week, 3.85, 3.95, 3.43 and 4.00 lb.; and carcass percentage of unfasted live weight increase 46.7, 46.2, 48.5, and 46.5. The Southdown cross appears to have grown distinctly more slowly than the others, so that the lambs had to be fed for a fortnight longer to reach 70 lb. live weight. This fact would have to be taken into account (with various others) when considering the average financial return per ewe in which the Southdown cross came second to the Suffolk cross with 45/9d. and 48/8 respectively. The experiments with the Masham ewes gave the same type of results. In most respects the results were remarkably similar for the three crosses. In comparison with the Cheviot cross lamb, the Masham cross lambs were heavier at birth and grew more quickly, but did not become fit for marketing until they weighed about 10 lb. more.

A.D.B.S.

Herefords and their Crossbreds in the U.S.S.R.

A. S. KARPOFF, O. W. GARKAWY, H. F. KUSHNER, and others. 1936.

This book, running to 212 pages, summarises the work carried out by the Orenbourg Research Institute with Hereford cattle.

With characteristic thoroughness the Russian Government has set apart a region of 500,000 square kilometres in Kazakhstan and Orenbourg. In this area it appears that Herefords and their crosses are to be the principal, if not the only, cattle.

A preliminary paper deals with the area, which is divided into four regions, with average monthly temperatures varying from 12--24° C. and rainfall varying from 235—361 mm. a year. Apparently the area, which is semi-desert and steppe, with drought localities, is not unlike the southern States in the U.S.A. in which the breed thrives.

From 1928 to 1932 Herefords were imported from England and Uruguay. The English imported stock made better live weight gains than that from South America, and as regards the majority of body dimensions the English animals are better developed.

The milking capacity of these Hereford cows at the Salsky Station is given in detail. On a 300-day basis the average lactation yield is about 300 gallons as heifers, rising to about 350 gallons in their third lactation. Some of the cows gave as much as 500 gallons in 300 days. The average fat content was 4.41.

In a paper dealing particularly with progeny born of parents imported from England on to three State farms, there are reported experiments on feeding different rations and the growth rate of steers and heifers. A correlation between weight at birth and weight at three months was found to + 0.25. In comparing the progeny of individual sires one bull, No. 1012, proved outstanding. At a second Station another bull, "Kray Despot," produced calves definitely heavier than those of other sires of the same breed.

The period of pregnancy for Hereford cows was found to be 281.67 days for bull-calves and 279.48 days for heifers.

There follows a paper on the breeding capacity of the different sires particularly as regards artificial insemination. Here the Uruguay bulls showed higher fertility than those from England. It was found that high condition of the sire bore a definite connection with the sperm quality. As a bull loses condition there is a lowering of the reproductive capacity. The author concludes that, to a great extent, the reproductive capacity of sires depends upon nutrition and husbandry. Scarcity of food and lack of exercise decreases the quality of the sperm as well as the sexual potency.

Next is a paper dealing with the diseases in the imported Hereford stock. Contagious Abortion decreased the milk yield by about 33 per cent. The progeny of different sires are differently affected by Contagious Abortion. Very little Tuberculosis was discovered (only .9 per cent. of 802 pure-bred animals). Considerable trouble, due perhaps to the white colour of the head, was experienced from "Telasia Rhodes." It is presumed that the white colour attracts the insects, which are carriers of Telasiosis.

In summer grazing there was a greater amount of hoof trouble in the case of the Hereford than in the case of the native stock.

The first observations on the native cattle of the district date from 1877, and are detailed in this paper. The animals in the area prior to the introduction of the Herefords are described as regards colour, body dimensions, milk productivity, skin measurements, etc.

Following this there is a paper on the first crosses, which, as a rule, show 10 per cent. greater weight at a year old than do the native stock. This difference increases with age. There are also given other measurements between the two types, and the writers conclude that it would be justifiable to use first cross bulls in regions where there is a shortage of purebred Hereford sires.

Another paper deals with a feeding experiment on both types, and another on the development of the carcase. Here the first crosses are intermediate between the Hereford and native stock A.D.B.S.

Jerseys; Some Results of Eighteen Years Close Breeding with

W. M. Regan, S. W. Mead, and P. W. Gregory. 1936. *J. Dairy Sci.*, *19*, 430-1.

In the spring of 1918 the pedigree Jersey herd at New Jersey Experiment Station consisted of three bulls and twenty-two females,

and embarked on an experiment designed to fix production through inbreeding and selection. Four years later twenty-nine Jerseys owned by the California Experiment Station were added, but since then no outside blood has entered the herd, and sire to daughter matings are practiced. When necessary to replace a bull, his most highly inbred son, out of a cow possessing desirable type and production, was selected to take his place. The productive capacity of all females was determined in the New Jersey herd, while the transmitting ability of bulls for both production and defects was determined in the herds of co-operating farmers.

The results of 197 dam : daughter comparisons shows an average increase for the daughters of 46 lbs. of fat. The daughters of every bull have averaged better than their dams.

Production records have been obtained on inbred animals carrying 75 per cent., and a few as much as 87.5 per cent. of the blood of their sire, but the number is small. There is no loss in body size or breeding efficiency.

The following recessive defects have appeared · hairless, congenital blindness, and a form of achondroplasia. A.D.B.S.

Large Black Sows; Milk Production in

F. N. Bonsama and P. M. Oosthuizen. 1935. *South African J. Sci.*, 32, 360-78.

Economical production in terms of the sow depends almost entirely upon the rate and economy of gains in total live weight of the litters reared. In this connection it must be remembered that the rate of growth and development of the suckling pig surpasses that of all other farm animals. Thus fertility and milk producing ability of sows are of fundamental importance. The young pig is remarkable amongst farm animals in that it is able to utilize feeding stuffs, other than milk, at a very early age. It is therefore essential to know how far the milk production of the sow influences the growth of the sucking pigs.

In this experiment purebred Large Black sows were used from different female families bred over several generations at the farm of the University of Pretoria. From the herd records some of these strains were known to be of low fertility, and to be poor mothers. The figures are based on fifty-two lactations produced by twenty-five sows. Results obtained from nervous sows were discarded, and likewise those from sows which became ill or lost their young. The sows ranged from one year one month to five years five months at the time of farrowing.

The method of estimating their milk production was to separate the litter from each sow for one day and night at the end of the week. During this day the litter was allowed to suckle the sow at definite intervals varying from two to three hours. The litter was weighed immediately before and after suckling, and the sum of the increases in weight recorded throughout the day and night was taken as indicative of the milk yield of the sow for that particular day. This figure, multiplied by seven, was taken as representing the milk yield of the sow for the week. Obviously the method is approximate, and this fact must be borne in mind in considering the results. Throughout the experiment the sows were fed upon the same ration, which was fed twice daily in the form of slop. No skim milk was used. All litters were weaned at twelve weeks.

The average total milk production for the eight weeks following farrowing was found to be 366.7 lbs. A considerable variation was observed in the total yield of the different sows, the highest being 584.1 and the lowest 184.6. While there may be some objection to the method used, the outstanding fact of this part of the investigation is the tremendous variability in milk yield amongst these twenty-five sows. Actually these figures agree wonderfully well with the results of previous investigators, the most reliable of whom estimated the average production per sow at 388, 411, and 401 lbs.

The average litter size for the lactation analysed was 6.67, hence the deduction is made that the average milk production of the Large Black as a breed is probably higher than the figure quoted above in view of the fact that the fecundity of this group of sows was lower than the average of the breed.

The average weekly milk production rose from about 45 lbs. in the first week to nearly 60 lbs. in the third, after which it steadily decreased to about 30 lbs. in the eighth week.

A close connection was found between litter size and total milk production per sow, the larger the litter, the more milk was produced.

With regard to litter size and total yield of milk per piglet, it was found that as the size of the litter increased, the amount per piglet definitely decreased. Thus, although total milk yield increased with increase in litter size, the total amount of milk available per pig reared decreased with litter size.

Examining in detail the different sows, it was observed that those with an inherent tendency to high milk production were capable of producing more milk per piglet even with larger litters than sows which were genetically low producers with small litters. Although milk production is influenced by litter size, the milk yielding potentialities of a sow are not primarily determined by the size of the litter. This is a point of considerable importance in the selection of breeding pigs. Since fecundity and milking capacity are two separate hereditary qualities, they should be considered as such by the breeder. While prolificacy is of primary importance, its value will be considerably reduced if it is not associated with good nursing qualities.

The amount of milk available per piglet is closely related to the average weekly gains in the body-weight of the sucking pigs. There is a high positive correlation between milk yield and average weekly gains in body weight.

The fact that piglets from small litters, owing to their more rapid growth, are capable of consuming more of the ration fed at an earlier age than those from larger litters, possibly accounts for the comparatively greater gains made by the smaller litter. On the other hand, a natural tendency was observed for piglets receiving a large quantity of milk to consume less of the ration fed than piglets from litters where the milk production per piglet was low.

The writers quote an authority to the effect that the average amount of milk required per lb. of live weight produced during the first four weeks following farrowing is 4.59 lbs. They are of opinion that this is low.

There was found to be no definite connection between the body weight of the sow, as recorded a week after farrowing, with the total

milk production, but it was definitely ascertained that, other things being equal, the greater the body weight, then the smaller would be the size of the litter. A tendency was noted for the medium sized sows weighing around 400 lbs. to be more prolific than the unduly heavy sows weighing 500 lbs. or more.

In dairy cattle it has been shown that the milk production of cows increases up to about the fifth or sixth lactation, and thereafter decreases. While these figures from South Africa cannot be accepted as conclusive, the results suggest that there is a marked increase in the milk yield from the first to the second lactation. The difference between the second and third and fourth is small, but thereafter a definite decline sets in.

Since fertility and milk production are hereditary, the sows from the different strains were grouped together for comparison. In spite of the small numbers of sows from each family some striking results were obtained from an anlysis of the blood lines in this respect. The superior milking capacity of two animals was most noticeable. An examination of the female lines showed an appreciable variation in fecundity and milking capacity from sows of different female lines which the authors attribute largely to hereditary causes. They emphasize the need for careful selection for prolificacy and nursing qualities in breeding pigs.

There remains some other observations. For instance each piglet selects and utilises a single teat during the whole period of suckling. It was noticed that within the first three days after the birth of a litter each of the piglets chose a teat, and that this teat was suckled only by the particular piglet until weaning. When a death occurred in the litter it was noticed that the pig on the adjacent teat would utilise both teats. All the teats were in-milk immediately after farrowing, but the number remaining in-milk was determined by the size of the litter and teats not suckled soon ceased to secrete milk. There were, however, exceptions, and in one case a litter of four actually used nine teats. The piglets showed a definite preference for the anterior teats, that is those nearer the head of the animal. It would appear that the selection of the forward teats is associated with a more liberal secretion of milk. This idea is supported by the observations which showed that the piglets suckling the forward teats were generally superior. A.D.B.S.

Litters; Variations in—According to Month Farrowed

(1936). *The Pig Breeders' Gazette*, No. 36, August.

These figures are based on the records of the pedigree breeds in the N.P.B.A. On the whole pedigree breeders tend to arrange their matings so that the bulk of their litters are born in January and July, and farrowings in October, November and December are avoided as much as possible.

There is not much difference in the size of litters born according to the month of the year. From the graph the figure varies from approximately 8.75 to 9.25. There is somewhat more variation in the number of pigs reared, which seems to vary from 6.6 to 7.5. More pigs are reared in litters born between May and October than at other periods of the year. A.D.B.S.

Pig; The Genetics of the

A. D. Buchanan Smith, O. J. Robison, and D. M. Bryant. (1936). *Bibliographia Genetica, 12*, 1-160. (Obtainable from the Institute of Animal Genetics, University of Edinburgh, 3/6).

This reviews all that is known on the subject of the inheritance of qualities in the pig. It is divided up into sections dealing with the inheritance of colour, physiological characters, disease resistance, prolificacy, sterility, and abnormalities. There are also two large sections dealing with the productive qualities and methods of improvement.

There is a full bibliography, and both an author and a subject index.

A.D.B.S.

Pigs; The Production of High-Grade

V. C. Fishwick. (1936). *J. Min. Agri.*, 43, No. 3, 235-40.

Sixty-eight crossbred pigs were reared, all sired by the same Large White Boar. Thirty-eight (Type I) were out of Essex Saddleback sows, and thirty (Type II) were out of Large Black sows. In addition two groups were formed cutting across the types. Group I received standard mixture, receiving a quantity of food they could clear up readily. The maximum daily ration fed to pigs in Group II was restricted to 5½ lbs. per head per day, and they did not receive that quantity till they reached 175 lbs. live weight, at which period Group I were receiving 6¾ lbs. The effect of limiting the ration was to produce a reduction in the thickness of the shoulder fat. The reduction was of considerable magnitude in Type I (out of Essex sows), but was insignificant in the case of Type II (out of Large Black sows). It was also noticed that there was a clearly marked difference in the thickness of the shoulder fat of the pigs of each type, Type II having greater thickness. Since all the pigs had the same sire the difference must have been entirely due to the dams.

Grading results showed that Type I improved in quality on the restricted ration, while Type II were approximately equally good irrespective of the ration.

Meal consumption varied from 481 lbs. per 100 lbs. carcase increase with Type I on Group I ration, while on Group II ration the figure was 486 lbs. Type II on Group I ration gave 502 lbs., and on Group II ration 510 lbs.; the method of nutrition having thus a small, if any, effect on economy of food consumption, but Type I appeared to have been more economical than Type II. This may be explained in the carcase measurements since these were fatter pigs, and it takes more food to produce a pound of fat than a pound of lean meat.

A.D.B.S.

Progeny Testing; Genetic Aspects of the Danish System of

J. L. Lush. 1936. *Iowa Agr. Exp. Stn. Res. Bull.*, 204.

The paper deals with the effect of pig testing in Denmark, where some eight hundred litters are tested annually in five official Stations. (There are also fifteen unofficial Stations). In 1923 the pigs at the Testing Stations averaged 1.2 lbs. daily live weight gain. By 1935 this had been increased to about 1.4 lbs. Similarly the pigs have become more efficient. The amount of food consumed per pound of live weight

gain has decreased in the same period from 3.63 lbs. to 3.36 lbs. Thus the pig keepers of Denmark are producing the same pigs as they did in 1928 in about twenty days less time (consequently with a quicker turnover of cash), and with about 8 per cent. less food. Dr. Lush is of the opinion that these improvements are largely due to improved breeding methods resulting from the wholehearted use of the Testing Station by the official breeders at the breeding centres.

Before 1926 no special interest was taken in body length. Since then the length of the Landrace has been increased by 3.3 cms., and has now reached the desired maximum length. The problem facing breeders in Denmark now is to reduce the variability of their pigs. Since 1923 there has been a reduction in the back fat amounting to .5 cms., and an increase in the belly of about the same amount.

Having achieved this, the tendency is now to lay greater emphasis on the quality of the flesh, particularly its firmness Likewise there is evidence that the killing percentage is primarily conditioned by hereditary factors. In 1925 40 per cent. of the pigs were made into Class I bacon. By 1935 this figure had been practically doubled, and now stands at 75 per cent. of the whole production.

Thickness of back fat and thickness of belly are more highly hereditary than are the other characteristics studied. Rapid live weight gain is very closely associated with economy of gain. The more rapidly the pigs grow, the less food will they eat per pound live weight gain. The thicker the belly, the higher will be the yield of export bacon. The longer the pig, the thinner will be the back fat

Without the use of the Testing Station method the author doubts whether these results could possibly have been achieved.

A.D.B.S.

Romney Sheep; Hairy Fibres of the

F. W. Dry. (1933). *New Zealand J. Agri.*, 46 and 48.

This is a technical paper dealing with the subject of the effect of environment, age, and heredity upon the production of kemp fibres in the fleece. A.D.B.S

Sheep: Sex Physiology of

Lucien L. Roux. *Onderstepoort J. of Vet. Sci. and Animal Industry*, Vol. 6, No. 2 (1936), 465-718.

In South Africa, the Merino, which is of great economic importance, does not breed so well as in Australia, its fertility having been put as low as 77 per cent. by some. The present work is a contribution to the physiology of breeding, dealing more especially with the fertility of that breed in South Africa, where the variations in climate and food supply give ample scope for such an investigation. After a review of relevant literature, the author discusses observations over a two-year period on a group of non-pregnant Merino ewes, the lots having been fed for long periods on different diets and tested at short intervals for oestrus. In addition, the sheep were weighed, and at the end of the period examination of the ovaries and uteri were made. Of the nine groups, six were on dry diets, and the remainder on pasture supplemented in various ways. All groups showed restricted annual sexual activity. (In parts of Australia and S. Africa, the Merino has non-restricted activity, having

a continuous series of heat periods through the year). In the pasture groups, sexual activity increased when the body weight decreased in autumn, but decreased in the spring, when there was a rapid rise in body weight. There was great individual variation within the groups. The experiment did not reveal the cause of the restricted activity, but suggested that it may be influenced by nutritional conditions. Nutritional factors had an important influence on the degree of polyoestrum (*i.e.*, recurrence of heat periods in a season), and constant green grazing had a marked effect in stimulating ovarian activity.

A number of the above sheep were slaughtered in the anoestrus period for a microscopical examination of the ovaries and for weighing the uteri. Spurious ovulation, *i.e.*, the occurrence of ovulation without oestrus during the anoestrus period, was found to be controlled, to some extent, though by no means entirely, by nutrition. Thus, on a dry ration for a protracted period, with only hay, bone meal and salt, there was no spurious ovulation, while on pasture supplemented by concentrates, this occurred in 86 per cent. of the cases. The level of nutrition also affected the weight of uteri, and, in young sheep, poor food over extended periods inhibited the development of the uterus.

The duration of oestrus, dioestrum and of the dioestrus cycle was determined by frequent observations, using vasectomised teasers. The onset of oestrus was abrupt, and its mean duration was thirty hours, though there was great individual variation.

Changes in the external genitalia, reported for some other breeds, were not observed in these Merinos After parturition the ewes of this breed that were allowed to rear their lambs to the age of five months did not come on heat but, where the lambs had been removed immediately, oestrus occurred within two months.

The restricted annual sexual activity of the Merino led to observations on the Suffolk-Blackhead Persian cross, and the Blackhead Persian-Merino. There was restriction in both, and, in the former sexual season was four to six weeks shorter than in the Merinos. The age of sexual maturity is of great importance in some countries, but, in the eastern Transvaal is overshadowed by the problem of internal parasites in young sheep. It was found that oestrus occurred in neither Merinos nor in Border-Leicester-Merino crossbreds before the age of one year; Merino female sheep have, under other conditions, been reported sexually mature at 9-10 months. Observations at another centre showed that the Welsh mountain-Ronderib was the first cross to exhibit oestrus, being sexually mature at 7½ months. It is interesting to Welsh readers to note that these crosses are reported as being rapid growers.

Experiments, as not yet completed, have been carried out on the effect of climate on the sexual activity of young ewes, these having been transferred from the Karroo to the eastern Transvaal highveld; the conditions in the former area are much more favourable for sheep farming, the pastures being more nutritive and not subject to the drastic reduction in value in the dry summer months. The change appeared to have some effect on the duration of the sexual season; the number of dioestrus cycles was reduced by 54 per cent. When a supplementary ration was fed at the Transvaal centre, increased body weights and sexual activity were noted.

The author concludes with a study of the breeding histories of

ninety of the most prolific Merino ewes from three flocks, and concludes that every effort should be made to secure breeding at an early stage, since postponement reduces fertility and fecundity. This book is a substantial contribution to the study of climate, nutrition and management on reproduction, and will interest both the student of general animal husbandry and the research worker; a wealth of data, and of details of the several histories, etc., of ewes is included. E.J.R.

Pork; Soft

(1936). *Armour's Monthly Letter to Animal Husbandmen*, 15, No. 1.

There are two principal causes of soft pork, an American term which includes bacon. The first is due to the natural characteristics of the hog. There is no question but that there are some inherited differences with reference to firmness of flesh between different breeds of pigs, and probably between different strains within a breed A study by Purdue University has shown that in general the British breeds of pigs have a tendency to make a firmer fat at lighter weights. The American breeds first lay on a soft fat, which becomes firmer, but not before the pigs have reached over 225 lbs. live weight. Thus, the rate of maturity is a question of some importance in fattening pigs. It is only fair to note that there are certain strains in some of the American breeds which definitely show an ability to put on hard fat at lighter weights.

The principal portion of this paper, however, deals with the effect of feed. It is maintained that when pigs are full fed mature maize (corn) they do not, as a result, produce soft pork, which is caused by feeds other than maize

The principal criminal in the United States is Soybeans. On no account should Soybeans be grazed or fed as beans to pigs. Soybean Meal, from which the oil has been extracted, does not soften the pork, and may be used safely. A.D.B.S.

Toggenburg Goats; Effect of Early Breeding on the Milk Production of

O. C. Cunningham and L. H. Addington. (1936). *J. Dairy Sci.*, 19, 405-9.

The odds are definitely in favour of goats which have kidded for their second lactation as two-year-olds than goats which have kidded for their first time at two years of age. This is in direct contrast to the belief held by a large number of goat breeders. A.D.B.S.

Wensleydale breed of Sheep; Genetics of the

F. W. Dry. (1936). *J. Genetics*, 33, 123-34.

This work is based upon records from the flock of Wensleydale sheep belonging, from 1897 to 1922, to Mr. G. Goland Robinson in order particularly to investigate the intensity of selection. The breed is fitted for this subject since it is outstandingly fertile and the accepted colour standards, being what they are, a big proportion of the lambs born, not merely the blacks, but an appreciable percentage of the whites, have on this account no chance of being chosen for breeding. Colour inheritance, therefore, as well as fertility, bears on intensity of selection.

There is a discussion on the wool colour types which recapitulates previous work by the author in this herd.

The coloured condition of the sheep behaves as a simple recessive to white. As regards ear colour, the breed standard calls for the skin of the face and ears to be deep blue in colour. Homozygous white animals are lighter in colour inside the ears than heterozygous whites. It is only inside the ears that such a difference between the genotypes can be dedicated. The blue sheep of the breed are, therefore, mostly heterozygous whites, though they may occasionally be homozygous. Modifying colours play a large part in the determination of blue ear colour.

Monozygotic twinning is very rare, if indeed it ever occurs. The fertility is high, the average number of lambs per ewe put to the ram being 1.71. Of all the lambings 69 per cent. were multiple births. Fertility is higher at four and five years than at two and three years, this being partly due to decrease in barrenness and abortion. Within the flock differences of unborn fertility were not discovered.

In Wensleydale crosses high fertility is transmitted by the Wensleydale rams to their crossbred daughters. A.D.B.S.

AGRICULTURAL BOOKS, 1936.

The following list, prepared by the staff of the National Library of Wales, is a selection of the more important books on the science and practice of agriculture published during the year 1936, together with a few omitted from the list for 1935. The list supplements *The Hand List of Books on Agriculture* issued by the National Library, third edition, 1926, copies of which can be obtained on application to the Librarian, The National Library of Wales, Aberystwyth.

BARKER, A. S. The use of fertilizers . . . London : Oxford University Press, 1935. pp. x, 204 ... ... 7s. 6d.

CARRIER, E. H. The Pastoral heritage of Britain . . . London : Christophers, 1936. pp. xii, 294. front., pls., map ... ... 10s. 6d.

CLARKE, G. R. The Study of the soil in the field. Oxford : Clarendon Press, 1936. pp. 142. diags. ... 5s. 0d.

COMBER, N. M. An introduction to the scientific study of the soil . . . (*3rd. ed.*). London : Arnold, 1936. pp. viii, 206. diags., bibl. ... ... 7s. 6d.

DAVIES, W. L. The Chemistry of milk. London : Chapman and Hall, 1936. pp. xii, 522. diags., bibl. ... 25s. 0d.

DOANE, R. W., *and others*. Forest insects . . . New York : McGraw-Hill, 1936. pp. xii, 464. front., ill., diags., bibl. $4.50

GARNER, H. V., *and others*. Profit from fertilizers . . . London : Crosby Lockwood, 1936. pp. 176. pls. 7s. 6d.

HADFIELD, MILES, *Editor*. The Gardener's Companion . . . London : Dent, 1936. pp. xvi, 624. col. front., ill., diags., bibl. ... ... 7s. 6d.

HANLEY, J., *Editor*. Progress of milk technology. Vol. I. Liverpool : J. Bibby & Sons, 1936. pp. 188. front. (port.), diags. ... ... 11s. 6d.

HARVEY, W. C., *and* HILL, H. Milk production and control. London : Lewis, 1936. pp. viii, 556. ill., diags. 21s. 0d.

INTERNATIONAL CONFERENCE OF AGRICULTURAL ECONOMISTS. St. Andrews, Scotland, 1936. Proceedings. London : Oxford University Press, 1937. pp. xiv, 528. front., pl., diags. ... ... 17s. 6d.

KEEBLE, *Sir* F. W., *and* RAWES, A. N. Hardy fruit growing. London : Macmillan, 1936. pp. xii, 334. pls. 16s. 0d.

MACMILLAN, H. F. Tropical planting and gardening . . . *4th ed.* London : Macmillan, 1935. pp. x, 560. col. front., ill. ... ... 25s. 0d.

MARTIN, H. The Scientific principles of plant protection . . . *2nd ed.* London : Arnold, 1936. pp. xii, 316. bibl. ... ... 21s. 0d.

MAXTON, J. P. *Editor.* Regional types of British agriculture. By fifteen authors. London : Allen and Unwin, 1936. pp. 318. maps ... ... 12s. 6d.

OXFORD : *University. Agricultural Economics Research Institute.* The History of milk prices . . . by R. L. Cohen. Oxford : The Institute, 1936. pp. xiv, 206 ... ... 5s. 0d.

Studies in power farming. I. Mechanised corn-growing, by A. Bridges and H. Whitby. II. The Cost of tractor work, by J. R. Lee. Oxford : The Institute, 1936. pp. 78 ... ... 2s. 6d.

PROTHEROE, R. E. *Baron Ernle.* English farming past and present . . . *New ed.* Edit. by Sir A. D. Hall. London : Longmans, Green, 1936. pp. xvi, 560. bibl. ... ... 15s. 0d.

ROBINSON, G. W. Soils . . . *2nd ed.* London : Murby, 1936. pp. xviii, 442. pls., ill., diags., bibl. ... 20s. 0d.

RURAL RECONSTRUCTION ASSOCIATION. The Revival of agriculture : a constructive policy for Britain. London : Allen & Unwin, 1936. pp. 138. front., bibl. ... ... 8s. 6d.

RUSSELL, *Sir* E. J., *and* VOELCKER, J. A. Fifty years of field experiments at the Woburn Experimental Station . . . London : Longmans, Green & Co., 1936. pp. xviii, 392. front. (port.), pls. ... 21s. 0d.

SHARPLES, A. Diseases and pests of the rubber tree. London : Macmillan, 1936. pp. xviii, 480. col. pls., ill., diags., bibl., diags. ... ... 25s. 0d.

SNOWDON, J. D. The Cultivated races of Sorghum. London : Trustees of the Bentham-Moxon Fund, 1936. pp. viii, 274. diags., bibl. ... ... 10s. 6d.

STAPLEDON, R. G., *Editor*. A Survey of the agricultural and waste lands of Wales. London: Faber and Faber, 1936. pp. xvi, 144. fdg. pls., fdg. map. 15s. 0d.

SUTTON *and Sons*. The Culture of vegetables and flowers from seeds and roots . . . *19th ed.* London: Simpkin, Marshall, 1936. pp. viii, 458. ill., diags. ... ... 6s. 6d.

TAYLOR, H. V. The Apples of England. London: Crosby Lockwood, 1936. pp. 266. col. front., pls. ... 21s. 0d.

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AGRICULTURAL LABOUR IN WALES UNDER STATUTORY REGULATION OF WAGES 1924—1937.

By A. W. Ashby, M.A., and J. H. Smith, M.Sc.,
University College, Aberystwyth.

Apart from a space of about three years between 1921 and 1924 wages and conditions of employment in agriculture have since 1917 been fixed by representatives of employers, employees, and the State and enforced under statute law. Until 1917 detailed information of rates of pay and conditions of employment were difficult to obtain and local customs were so strong that it was difficult to make any generalisations about practices within a county or in some cases within a parish. Information collected by various government agencies indicated that in 1914 for ordinary workers in England the net value of cash wages and payments in kind amounted to 18s. per week. If there was any difference in Wales the comparable figure would not be below 17s. 8d. per week but for purposes of this study the averages have been taken at 18s.

Since 1917 more accurate information is available. Although the function of the National Wages Board set up under the Corn Production Act, 1917, was to fix weekly minimum wages it was compelled to take account of hours of labour and to assess the value of cottage rents, board and lodgings and other payments in kind. Under the Agricultural Wages Act, 1924, members of Agricultural Wages Committees for each of the administrative areas have defined the range and value of goods and services which may be included as part payment for work done.

In 1918 the average wage paid to ordinary male workers in Wales was 31s. 10d. or 77 per cent. above the pre-war level of 18s. Between 1918 and 1921 the minimum rate steadily increased and in the latter year it was 44s. 2d. per week or 145 per cent. above the pre-war level.

In 1921 the Corn Production (Repeal) Act was passed and substituted Voluntary Conciliation Committees for the Agricultural Wages Board. It was recognised that both employers and employees were growing accustomed to the idea of collective bargaining and it was hoped to preserve this practice by the establishment of voluntary Conciliation Committees. But economic conditions were uncertain for both

farmers and workmen and in the absence of statutory enforcement of agreements there was soon a drift back to individual bargaining. By 1923 these Conciliation Committees had become ineffective, in many districts the meetings were discontinued and serious objections against the non-observance of agreements were being made by workers' organisations. At this time the average wages for ordinary workers in England and Wales was 28s. per week, and the comparable figure for Wales nearly a shilling higher at 28s. 11d. Thus weekly wages in England showed a much more important decline than occurred in Wales. In 1921 the weekly average wage in England and Wales was 146 per cent., and in 1924 it was only 56 per cent. above the pre-war level. At the time of the introduction of statutory regulation in 1924 average weekly wages in Wales stood at about 29s. 5d. and were some 7 points better than the average for England and Wales.

The Agricultural Wages (Regulation) Act became operative in August 1924 and for its operation Wales and Monmouth was divided into 8 administrative areas, each having a Committee composed of six representatives of employers and employees respectively, and two impartial members appointed by the Minister of Agriculture with an independent Chairman appointed by the Committee itself.[1] The Committee for Anglesey and Caernarvon was the only one in Wales to secure by the end of that year an order affecting the wages and conditions of employment but by March of 1925 orders were in force in all the other areas.

The immediate effect of the operations of these committees was to increase the weekly average wages of ordinary farm-workers by 1s. 7d. per week to an average of 31s. in 1925. Increases in the minimum cash wages were obtained in 1926 and 1927 and in the latter year the average wage was the highest for Wales since the introduction of the present Act. From 1927 until 1933 minimum weekly rates were on the down grade, in the first three years the reduction was only 5d. but in the latter year the average was 1s. 7½d below that for 1927. Since 1933 improvements have been obtained and the average for 1937 at 31s. 7½d. was 1s. 6d. higher than that of 1933.

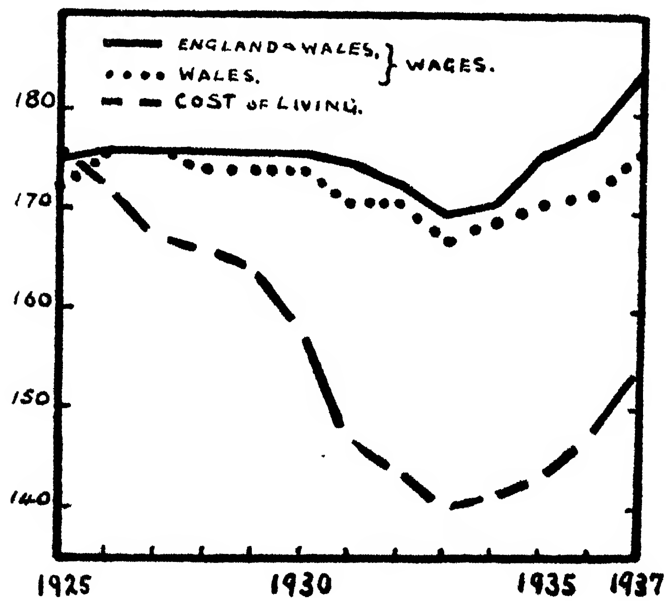
During the first three years of the operation of the present Act the averages of weekly rates for Wales compared

[1] Or in the event of failure of agreement the Chairman is appointed by the Minister of Agriculture.

favourably with those for England and Wales. Since 1927, however, the average rates for Wales have been lower than those for England. In the period of declining wages from 1927 to 1933, the average rates for England and Wales were 2 to 3 points higher than those for Wales but in recent years farm-workers in England have obtained somewhat greater improvements in their cash wages and in 1937 the average for England and Wales was eight points higher than that for Wales. Minimum rates in Wales were more easily reduced during the period of general decline in the economic conditions of agriculture and failed to respond as quickly to the recent improvements in the industry. The following figure shows the changes which have taken place since 1925.

FIGURE I.

Changes in Minimum Wages and Cost of Living.



The minimum rates operating in each of the eight areas show some important differences. In individual years the margins between the highest and lowest minimum rates ranged from 7s. 6d. in 1925 to 3s. in 1932, but the most common differences have been from 4s. to 5s. 6d.. In every year the highest rate was fixed by the Committee operating in the county of Glamorgan and during the nine years 1928 to 1936 inclusive the lowest rate affected workers in the counties of Merioneth and

Montgomery. The lowest rates in 1925 were operating in Carmarthen and in Anglesey and Caernarvon, and in 1926 and 1927 the lowest were found in Denbigh and Flint.

TABLE I.

Highest and Lowest Minimum Rates for Ordinary Adult Workers in Wales and Monmouth.

Year.	*Highest.*	*Lowest.*	*Difference.*	*Year.*	*Highest.*	*Lowest.*	*Difference.*
	s. d.	*s. d.*	*s. d.*		*s. d.*	*s. d.*	*s. d.*
1925	37 6	30 0	7 6	1932	31 6	28 6	3 0
1926	36 0	30 6	5 6	1933	32 6	27 0	5 6
1927	36 0	30 6	5 6	1934	33 6	27 0	6 6
1928	34 0	30 0	4 0	1935	33 6	28 6	5 0
1929	34 0	30 0	4 0	1936	33 6	28 6	5 0
1930	35 0	30 0	5 0	1937	34 6	31 0	3 6
1931	35 0	30 0	5 0	Current	36 0	31 6	4 6

In seven of the eight years following the introduction of legal control in 1924 four of the eight committees operating in Wales fixed minimum rates for ordinary adult male workers of 31s. to 32s. per week and in 1927 five committees fixed rates within that range. In 1933 and each subsequent year there has been a greater variety of rates and the following table indicates the rates fixed.

Of the rates for the separate areas those for Glamorgan have undergone the greatest change. In 1925 a rate of 37s. 6d. per week was fixed but by 1929 it had been reduced to 34s. An increase of 1s. per week was obtained during the following year but in 1932 the rate was reduced to 31s. 6d., which was 6s. below that fixed in 1925. Since 1932 increases amounting to 4s. 6d. per week have been obtained. For Merioneth and Montgomery the rate was 31s. per week in 1925 and was increased by 6d. in the following year. In 1928 the rate was reduced to 30s. and remained at this level until 1932 when a further reduction was made and by 1933 it had fallen to 27s. per week. In 1934 the rate in Merioneth and Montgomery was 2s. 6d. below the next lowest and 6s. 6d. below the highest weekly rate. The remaining six committees made changes over the period of thirteen years ranging up to 2s. 6d. per week and in one particular case a change, an increase of 6d. per week,

TABLE II.

Weekly Minimum Rates of Wages for Ordinary Adult Male Workers.

Year.	Wales. *27s. and under 29s.*	*29s. and under 30s.*	*30s. and under 31s.*	*31s. and under 32s.*	*32s. and under 33s.*	*33s. and under 34s.*	*34s. and under 35s.*	*35s. and over.*	England. *27s. and under 29s.*	*29s. and under 30s.*	*30s. and under 31s.*	*31s. and under 32s.*	*32s. and under 33s.*	*33s. and under 34s.*	*34s. and under 35s.*	*35s. and over.*
1924			1						1	1	1					
1925			2	4	1			1		3	15	3	9	2	4	4
1926			2	4	1			1			13	7	10	3	2	5
1927			1	5	1			1			14	7	10	2	2	5
1928			2	4	1	1					14	7	10	1	3	5
1929			2	4	1	1					14	7	10	2	2	5
1930			2	4	1			1			14	6	11	1	3	5
1931			2	4	1			1	1		13	7	11	2	2	5
1932	1	1	2	4					4		12	7	10	4	2	1
1933	1	1	3	2	1				4	3	17	7	6	1	2	
1934	1		4	2		1				2	18	10	5	4	1	1
1935	1		2	3	1	1				1	5	14	13	4	2	2
1936	1		1	3	2	1						17	13	5	2	4
1937				2	1	3	2					1	10	9	12	9
Current				1	2	3	1	1						10	14	17

occurred last year. The following summary indicates the differences in the present rates as compared with those first fixed in 1925.

Area.	*Change.*
Carmarthen	increase of 3s. 0d.
Pembroke and Cardigan	
Monmouth	
Anglesey and Caernarvon	increase of 2s. 0d.
Radnor and Brecon	
Denbigh and Flint	increase of 1s. 6d.
Merioneth and Montgomery	increase of 6d.
Glamorgan	decrease of 1s. 6d.

The rates operating in the areas of Carmarthen and of Denbigh and Flint have been subject to the least change during the period. Apart from the initial order of 1925 only four of those subsequently made by the Committee in the county of Carmarthen have affected the weekly wages and no alteration has been made in the hours of employment or overtime rates. No decrease in the rates of wages occurred and the rate has been increased on four occasions. The Committee operating in Denbigh and Flint made only two orders affecting the wages of ordinary adult workers and two affecting the hours of their employment. Ordinary adult workers in these counties have suffered no decrease in their wages and have on two recent

occasions obtained increases. The most frequent changes have been made by the Committees of Glamorgan and Merioneth and Montgomery. In both areas the wage rates have been decreased on three and increased on five occasions. In Radnor and Brecon changes were made on five and in Monmouth on four occasions. The number of general orders made in Wales since the introduction of the present Act is 135, and 51 of these have affected wages alone or wages and some conditions of employment. In 69 cases no change was made in the existing general wages rate and conditions of employment.

Changes in Minimum Rates for Ordinary Workers in Wales Number of Changes since 1925

District.		*Change.*	
Denbigh and Flint	. . ...	2 increases.	0 decrease(s)
Pembroke and Cardigan	... ..	4 ,,	1 ,,
Radnor and Brecon	... ...	4 ,,	1 ,,
Carmarthen	.. ..	4 ,,	0 ,,
Anglesey and Caernarvon	... ...	4 ,,	1 ,,
Monmouth	... ...	2 ,,	2 ,,
Glamorgan	... ...	5 ,,	3 ,,
Merioneth and Montgomery	..	5 ,,	3 ,,

Net Changes each year in 8 Districts.

Year.	*No Change.*	*Increase.*	*Decrease.*
1926 ...	6	1	1
1927 ...	8	—	—
1928 ...	6	—	2
1929 ...	8	—	—
1930 ...	7	1	—
1931 ...	8	—	—
1932 ...	3	—	5
1933 ...	5	1	2
1934 ...	4	4	—
1935 ...	4	4	—
1936 ...	5	3	—
1937 ..	—	8	—

Seven of the Welsh Committees fixed the period during which a particular order is to operate, the remaining one of Anglesey and Caernarvon have allowed their orders to operate for indefinite periods. In three cases the duration of the order now in force is for one year; in two cases for six months; in one case for one year and in one for six months "unless otherwise ordered." During the period 27 general orders have been made by the Committee for Radnor and Brecon and those made since 1929 have been for six monthly periods. In Anglesey and Caernarvon, on the other hand, only 18 orders have been made and the duration of these has varied from 8 to 25 months.

Between 1926 and 1931 the rates were remarkably stable. Only three decreases occurred, two in Glamorgan and the other in Merioneth and Montgomery. Only two increases occurred, one in Carmarthen and the other in Glamorgan. The Glamorgan rates have been erratic, and shown changes irrespective of changes in the economic condition of the industry. The greatest number of changes occurred in 1932 when there were five decreases and in 1937 when there were increases in every district.

Wages of Special Classes.

Special rates of pay and conditions of employment for special classes—shepherds, stockmen, horsemen, etc.—have been fixed for the four areas of Anglesey and Caernarvon, Denbigh and Flint, Merioneth and Montgomery and Glamorgan. In the remaining four areas these classes of adult workers receive the ordinary rates of pay together with the general overtime rates for time worked in excess of the weekly minimum. In 1925 the minimum rates fixed for special classes varied from 34s. in

TABLE III.

Weekly Minimum Rates for Special Classes.

Year.	*Anglesey and Caernarvon*	*Denbigh and Flint.*	*Glamorgan*	*Merioneth and Montgomery*	*Difference between lowest and highest rates.*
	s. d.	*s. d.*	*s. d.*	*s. d.*	*s. d.*
1925	35 0	37 0	40 0	34 6	5 6
1926	35 0	37 0	40 0	34 6	5 6
1927	35 0	37 0	40 0	34 6	5 6
1928	35 0	37 0	38 0	33 0	5 0
1929	35 0	37 0	38 0	33 0	5 0
1930	35 0	37 0	39 0	34 0	5 0
1931	35 0	37 0	39 0	34 0	5 0
1932	35 0	35 0	35 0	32 6	2 6
1933	33 0	34 0	36 0	31 0	5 0
1934	34 0	34 0	37 0	31 0	6 0
1935	35 0	35 6	37 0	32 6	4 6
1936	35 0	35 6	37 0	32 6	4 6
1937	36 0	36 6	38 0	34 0	4 0
Current	36 0	37 6	40 0	35 6	4 6

Weekly Rates for the Special Classes of Workers.

Area.	*1925.*	*1933.*	*Current.*
	s. d.	*s. d.*	*s. d.*
Glamorgan	40 0	36 0	40 0
Denbigh and Flint	37 0	34 0	37 6
Anglesey and Caernarvon ...	35 0	33 0	36 0
Merioneth and Montgomery ...	34 6	31 0	35 6

Merioneth and Montgomery to 40s. in Glamorgan, where these workers have enjoyed the highest rate in each year except 1932 when at 35s. it was only equal to those operating in Anglesey and Caernarvon and in Denbigh and Flint. The special rates fixed in Merioneth and Montgomery have always been below those for the other counties. In most years the difference between the highest and the lowest rates has been as much as 5s. and in one year it was 6s. Table 3 gives a summary of the changes which have taken place during the period under review. It is important to notice that only one separate rate for special workers has been fixed in any area: such special rates as have been fixed have been applicable to all special classes.[2]

In 1933 these rates were from 2s. to 4s. lower than in 1925 but at the present time Glamorgan is the only area which has not got a rate higher than the first fixed under the Act of 1924.

Ordinary Minimum Wages for Youths.

Separate rates of wages are fixed for youths under 21 years of age. Usually there are separate rates for young workers by yearly steps but in Carmarthen the same rate is applicable to all youths under 17 years of age while separate rates are determined for each " year " group from 17 to 21 years. These sets of rates of wages show considerable variations in the different areas of Wales, but differences are most marked in the rates applicable to youths under 18 years. The following table shows the range of differences between the highest and lowest rates for each age.

TABLE IV.

Difference between Highest and Lowest Rates for Workers under 21 years.

Year.	*20 and under 21.*		*19 and under 20.*		*18 and under 19.*		*17 and under 18.*		*16 and under 17.*		*15 and under 16.*		*14 and under 15.*	
	s.	*d.*	*s*	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*
1926 ...	6	0	5	6	5	0	6	6	7	6	8	0	7	6
1927 ...	6	0	5	6	5	0	6	6	7	6	8	0	7	6
1928 ...	4	0	4	0	3	6	5	6	7	6	8	0	8	0
1929 ...	4	0	4	0	3	6	5	6	7	6	8	0	7	6
1930 ...	4	0	4	0	3	6	5	0	5	6	6	6	7	6
1931 ...	4	0	4	0	3	6	5	0	5	6	6	6	7	6
1932 ...	3	0	2	6	2	0	4	6	5	6	6	6	6	6
1933 ...	4	6	3	6	3	6	4	6	5	6	6	6	6	2
1934 ...	3	6	3	5	3	6	5	0	6	0	6	6	6	2
1935 ...	5	6	4	0	4	0	5	0	6	0	6	6	5	7
1936 ...	5	0	4	0	3	6	5	0	6	0	6	6	6	7
1937 ...	6	0	5	0	1	6	6	0	6	0	6	6	5	0

[2] There are also special rates for forestry workers.

It will be seen that the range of differences in the wages of youths over 18 years of age was from 2s. to 6s., while for those under 18 years the difference was from 4s. 6d. to 8s. These differences are proportionately wider than those between rates for adult workers.

Until 1931 farmers in Glamorgan were required to pay the highest minimum wages for youths of ages ranging from 17 to 21 and during the same period those in the counties of Denbigh and Flint were paying the lowest rates to youths of all ages above 15 years. Since 1931 the highest rates for youths 17 to 21 years have in most cases been paid by farmers in Glamorgan and Monmouth, while farmers in Carmarthen, in Anglesey and Caernarvon, in Pembroke and Cardigan, and in Glamorgan, have at one time or another and for one or more of the age classes paid the highest rates for youths under 17 years of age.

Taking averages for the eight areas and for each age-group it is remarkable that the young workers under 21 years of age suffered less reductions than adults in the period of depression, and have gained less during the recent period in which rates have been rising. Rates for young "ordinary" workers are now practically at the levels established in 1926 while rates for adults are generally above that level.

TABLE V.

Average Weekly Minimum Rates for "Ordinary" Male Workers under 21 years of age.

Year.	*20 and under 21.*		*19 and under 20.*		*18 and under 19.*		*17 and under 18.*		*16 and under 17.*		*15 and under 16.*		*14 and under 15.*	
	s.	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*
1926 ...	29	4	26	9	24	1	20	10	17	11	15	7	14	3
1927 ...	29	4	26	9	24	1	20	10	17	11	15	7	14	3
1928 ...	28	10	26	4	23	8	20	4	17	6	15	3	13	9
1929 ...	28	11	26	5	23	10	20	7	17	8	15	5	13	11
1930 ...	28	11	26	7	23	[illegible]	20	4	17	4	15	7	13	8
1931 ...	28	11	26	7	23	8	20	4	17	4	15	1	13	8
1932 ...	27	8	25	5	23	2	19	5	16	5	14	4	13	0
1933 ...	28	1	25	9	23	0	18	6	16	9	14	6	13	4
1934 ...	28	0	25	8	22	11	19	8	16	8	14	7	13	3
1935 ...	28	6	26	1	23	5	19	11	16	11	14	9	13	5
1936 ...	28	8	26	3	23	6	20	2	17	1	14	11	13	7
1937 ...	29	2	26	8	23	11	20	8	17	5	15	2	13	8

The highest and lowest current rates for young workers are given below.

TABLE VI.

Current Rates of Wages for "Ordinary" Youths under 21 years of age.

Age Range.	Highest Rate. Area.	s.	d.	Lowest Rate. Area.	s.	d.
20 and under 21 ...	Monmouth	33	0	Denbigh and Flint	27	6
19 and under 20 ...	Glamorgan	30	0	do.	26	6
18 and under 19 ...	do.	27	0	do.	22	6
17 and under 18 ...	do.	24	6	do	18	0
16 and under 17 ...	Glamorgan, Pembroke and Cardigan	20	6	do.	14	0
15 and under 16 ...	Carmarthen	18	6	do.	11	6
14 and under 15 ...	do.	17	0	Monmouth	11	0

Only two of the areas, Glamorgan, and Anglesey and Caernarvon, have fixed rates for "special classes" under 21 years of age. In Glamorgan the current rates are 8s. 6d. higher than those for ordinary workers at 14 years of age, and 4s. 6d. higher at 20 years of age. In Anglesey and Caernarvon the differences tend to be wider, the rate for special classes at 16 years is 5s. higher than that for ordinary workers, while the rate at 20 years is 4s. 6d. higher.

Length of Working Week.

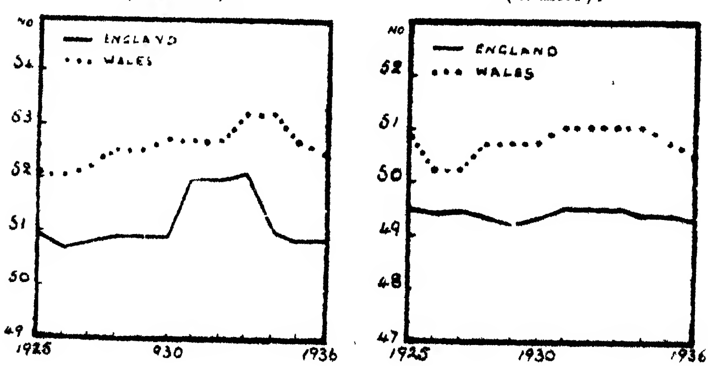
In order to make the statutory regulation of wages effective the committees had, amongst other things, to define the length of the working week. In four of the eight areas in Wales the maximum length of the ordinary working week applies to all classes of agricultural workers, while in the other areas separate hours are fixed for ordinary and for the special classes of workers.

FIGURE 2.

Weekly Hours of Employment.

(Ordinary Workers).

(Summer). **(Winter).**



The average ordinary working week in Wales has remained, over the period, about one hour longer than that for ordinary workers in England. Figure 2 shows that the average working week during the summer time increased from 52 hours in 1925 to just over 53 in 1933 and 1934. Since then some reductions have occurred and at the beginning of 1938 the average week for the summer period was again 52 hours. In 1925 the average working week during the winter period was nearly 51 hours. Reductions occurred in 1926 and 1927 but in 1928 and until 1930 it was again approximately 51 hours. Some increases took

TABLE VII.

Weekly Hours of Ordinary Workers in England and Wales.

I. Summer.

Year.	*Wales.* 48	52	53	54	*England.** 48	50	51	52	53	54	55-57
1925	8	1	1	3	1	17	4	10	1	7	
1926	4			4	1	19	4	9		7	
1927 . ..	3	1		4	1	18	4	9	1	7	
1928	2	2		4	1	18	3	9	1	8	
1929	2	2		4	1	19	3	8	1	8	
1930	2	1		5	1	19	3	8	1	8	
1931	2	1		5	1	13	1	12	4	7	2
1932	2	1		5	1	11	3	12	5	6	2
1933	1	1		6	1	10	3	13	4	7	2
1934	1	1		6	1	17	2	9	3	8	
1935	2	1		5	1	18	3	8	2	8	
1936	2	2		4	1	18	1	8	1	8	
1937	2	2		4	1	19	2	9		8	
Current ...	2	2		4	1	20	2	9		8	

II. Winter.

Year.	*Wales.* 48	50	51	52	54	*England.** 48	50	51	52	53	54
1925	1	4	1		2	23	8	2	1		6
1926	3	3			2	25	8	1			6
1927	3	3			2	25	8	1			6
1928	2	3		1	2	25	9	1			5
1929	2	3		1	2	26	8	1			5
1930	2	3		1	2	25	9	1			5
1931	1	4		1	2	23	9	1	1		6
1932	1	4		1	2	22	11	1			6
1933	1	4		1	2	23	10	1			6
1934	1	4		1	2	25	8	1			6
1935	2	3		1	2	24	9	2			5
1936	2	3		2	1	25	8	2			5
1937	3	2		2	1	26	8	1	1		4
Current ...	4	1		2	1	25	10		1		4

* Excluding part of Lancashire where the rate nominally fixed for ordinary workers is regarded as a special rate, and where it is fixed on a 60 hour week.

place in 1931 and the average then remained steady until 1935 when reduction occurred. The latest information shows that the average ordinary working week for the winter period is 50 hours, the lowest during the whole period.

More than half of the English districts have had a working week of 48 hours during the winter months. In Wales the number of areas with a working week of 48 hours varied from 1 to 3 in the years 1925 and 1936. Until 1936 two areas had a 54 hour week and another a week of 52 hours. The changes which occurred during the period were in the districts with the shorter hours. The ordinary working week fixed for the summer months in English districts shows greater variation in the years 1931 to 1933. Apart from these three years workers in about one fifth of the English and those in one half of the Welsh areas had a working week of 54 hours. The previous table shows a comparison of conditions in the districts of England and of Wales.

Public Holidays.

The practice of defining employment on certain public holidays as overtime has made little progress in Wales. Detailed information for 1930 shows that farmers in three of the eight areas had to pay their employees overtime rates for work done on Christmas Day and similar provision was made in Monmouth for all employment on four of the public holidays. The latest Orders show that in Carmarthen, Merioneth and Montgomery, and in Radnor and Brecon, employment on Christmas Day is to be reckoned as overtime. In Pembroke and Cardigan employment on Good Friday, Whit-Monday, August Bank Holiday and Christmas Day and in Monmouth employment on two additional days namely Easter Monday and Boxing Day is to be regarded as overtime.

By 1936 provision had been made in 32 districts in England against employment on one or more of the public holidays, in 13 areas the provisions cover two and in 13 other areas 4 or more public holidays. The following is a summary of the essential information.

Of the 37 Committees which made arrangements in 1936 for employment on certain public holidays to be treated as overtime 28 made further provisions whereby the weekly number of hours which workers are expected to work for the minimum wage is reduced by the hours they would have worked on the public

Public Holidays.

No. of Days.	*England.*		*Wales.*		
	1930.	*1936.*	*1930.*	*1936.*	*Current.*
1	2	1	3	4	3
2	14	13			
3	5	6			
4	1	5			1
5	1	4			
6	5	3	1	1	1
	28	32	4	5	5

holidays. No such provision was made by any Committee in Wales until 1937 when that for Pembroke and Cardigan limited the ordinary working week in those weeks in which the defined public holidays occurred to 46 hours. This is important since workers could otherwise be asked to increase their normal working day in such weeks in order to make up for the time lost. These general results show that workers in the English districts have obtained the more favourable concessions.

Rates per Hour.

Because of considerable variations in the hours fixed for the purpose of determining the minimum rates of wages it is not possible to get an easy comparison of rates between different areas. It will be remembered that in four areas the differences

TABLE VIII.

Minimum Rates per Hour of Labour.

	Monmouth.	*Anglesey & Caernarvon*	*Carmarthen*	*Denbigh & Flint.*	*Glamorgan.*	*Merioneth & Montgomery.*	*Pembroke & Cardigan*	*Radnor & Brecon.*
Ordinary Workers	*d.*	*d.*	*d.*	*d.*	*d*	*d.*	*d.*	*d.*
1925 Summer ...	7.68	7.20	6.67	7.32	8.49	7.00	6.67	6.89
1925-26 Winter ...	8.40	7.20	6.89	7.32	8.49	7.00	7.20	6.89
1933 Summer ...	6.89	7.08	6.89	6.78	7.50	6.00	6.67	6.55
1933-34 Winter ...	7.44	7.33	6.89	7.32	8.12	6.00	6.92	7.08
1937-38 Winter ...	8.16	8.30	7.33	7.75	8.62	7.15	7.61	8.25
1938- Summer ...	7.67	7.68	7.33	7.68	8.31	7.27	7.33	7.33
Special Classes								
1925 Summer ...		7.24		7.28	8.00	6.90		
1925-26 Winter ...		7.24		7.28	8.00	6.90		
1933 Summer ...		6.15		6.80	7.20	6.20		
1933-34 Winter ...		7.03		6.80	7.20	6.20		
1937-38 Winter ...		7.45		7.30	7.60	7.24		
1938 Summer ...		7.45		7.50	8.00	7.34		

between special classes and ordinary workers have been left to the influence of payment for overtime while in four other areas separate rates have been fixed for the special classes. The position is further complicated by the practice of fixing what are in effect different rates for the Winter and Summer periods. But the previous summary shows hourly rates in each of the areas when regulation first became effective, when rates touched their lowest points, and at the beginning of 1938. This summary shows clearly that rates in Glamorgan, although always relatively higher have not been so much higher than others as appears on first examination. The low position of Merioneth and Montgomery still remains.

Overtime Rates.

There have been very few changes in hourly rates for overtime of " Ordinary " Adult male workers. The following is the summary.

		All Overtime. *Pence*
Anglesey and Caernarvon	1925-37	9
Denbigh and Flint	..	9
Radnor and Brecon	..	9
Carmarthen	..	8½
Merioneth and Montgomery	..	9

	Sunday.	*Pence.*	*Weekday.*	*Pence.*
Monmouth	1925-37	11½	1925-37	9½
Glamorgan	1925-31	11	1925-31	10
	1932-37	10	1932-37	9
Pembroke and Cardigan	1925-27	9½	1925-28	8½
	1928-	8½	-	
	1929-31	9	1929-31	9
	1932-36	8	1932-36	8
	1937-	8½	1937-	8½

In the four areas in which no separate rates have been fixed for the special classes these rates for overtime also apply to all adult male workers, including the special classes. Glamorgan is the only area in which special overtime rates have been fixed, so that except in Glamorgan the rates here quoted apply to all adult male workers.

Rates for Females.

In all areas minimum rates for females have been fixed on the hourly basis. As in the case of males, different rates are fixed for young workers but the following summary shows the highest rate in each area.

Area.	*Period.*	*Pence per hour.*
Denbigh and Flint Merioneth and Montgomery Pembroke and Cardigan Radnor and Brecon Carmarthen	1925-37	5
Glamorgan	1925-38	6
Anglesey and Caernarvon	1925-37	6
	1938	6½
Monmouth	1925-36	6
	1937-38	6½

It is remarkable that workers' representatives on the Wages Committees have paid so little attention to these rates. Although they do not exercise any marked influence in the general costs of farming they have some importance in the direct costs of animal products, especially milk. But their stability under changing agricultural conditions shows the general disregard in which they are held.

Minimum and Actual Rates of Wages.

Information on actual rates of wages paid is available for only a comparatively small number of farms in Wales. In England it was estimated about 1934 that the cost of labour per week, including employer's contribution to National Health Insurance and cost of employers' liability insurance, together with actual payments to workers in cash and kind, was about 11 per cent. higher than minimum wage rates for both " high pay " and " ordinary " workers.[3] The Ministry of Agriculture provides a certain amount of information obtained in the course of inspections of which there are two types, namely test inspections of a routine character when farms are visited for the purpose of checking rates paid and conditions imposed and inspections made after receipt of complaints. From these inspections, if from no other evidence, it is clear that actual rates are made up of wages paid in contravention of the Orders at lower rates than those fixed, and of rates in excess of the minimum paid on agreement between employer and employee.

As regards underpayment, the evidence of test inspections is that cases are more frequent in Wales than in England. Underpayment appears to have been particularly prevalent in the early years of regulation up to 1928, and to have fallen to low proportions from 1928 to 1931 when it again became more frequent. Improvement in conditions has recently appeared. In England

[3] Carslaw and Graves: The Labour Bill and Output on Arable Farms. Journal of the Royal Statistical Society, Vol. 98, 1935.

the percentage of cases of underpayment has been much more steady at a lower level.

The nature of the underpayment is often trivial and in the majority of cases relates to failure to observe the conditions relating to the payment of overtime. The old customs of give and take in respect of hours of employment have had to give way to hard and fast rules but the old relationships have not been easily forgotten either by the employer or the employee.

TABLE IX.

Underpayment of Minimum Rates found in Test Inspections.

	England.			Wales.		
		Workers underpaid.			Workers underpaid	
Year.	*No. of Farms.*	*No.*	*% of Total.*	*No. of Farms.*	*No.*	*% of Total.*
1925-26	121	167	19.93	29	39	54.17
1926-27	621	587	20.68	67	72	43.64
1927-28	1,448	775	18.69	133	109	33.33
1928-30	1,235	812	17.72	201	76	10.37
1930-31	646	415	18.39	50	26	14.91
1931-32	749	552	20.35	11	16	22.22
1932-33	391	230	13.84	52	19	24.36
1933-34	383	219	13.26	57	37	10.22
1934-35	551	314	18.99	131	88	40.55
1935-36	884	623	20.92	169	102	36.04
Total	6,979	4,694	17.83	933	581	26.89

In some cases workers have persuaded employers to give them work of a casual character at a lower rate of pay. Inspections have revealed this form of underpayment and the farmer has found himself summoned for yielding to a persuasion to employ people he did not really require. But in other cases the evasions have been more or less deliberate.

It is unfortunate that information on rates of wages found on inspections is not available for England and Wales separately, for this is the most representative of fully checked data on actual wages now obtainable. The general effect of the evidence is that farmers were paying and workers were receiving from 1s. 6d. to 2s. 6d per week above the minimum rates fixed, but as this includes payment for overtime it appears that the rates paid for the hours fixed by Orders could not have been much higher than the minima.

TABLE X.

Actual Weekly Earnings of Workers on Farms visited by Inspectors in England and Wales.

Year.	*Ordinary Adult Workers.*	*Stockmen.*	*Horsemen.*
	s. d.	*s. d.*	*s. d.*
1927-28 ...	33 4	38 6	36 9
1928-30 ...	33 8	39 1	37 5
1930-31 ...	33 11	39 5	37 4
1931-32 ...	33 4	38 11	37 3
1932-33 ...	32 8	38 6	36 6
1933-34 ...	32 7	38 9	36 7
1934-35 ...	33 2	38 10	36 10
1935-36 ...	34 7	39 8	37 4

The Cost of Labour.

The ultimate cost of labour is the result of complex conditions, some of which many people are inclined to say are of moral character. The most common assumption, perhaps, is that cost of labour rises with rates of wages. But in actual practice cash cost is determined by the numbers of workers of different ages and sexes regularly and casually employed; the rates of wages paid for ordinary and overtime hours; the hours worked; and the amount of piece-work and the rates paid therefor. As farmers' relatives take such a large part in the work of farms these have been included in the total estimated amount of labour used, and although they are not subject to the regulations of conditions of labour it has been assumed that their earnings changed with the minimum rates. Farmers also take part in the manual work of their farms, and their wives sometimes make a contribution but in estimating the cost of labour it has been assumed that the work of the farmer and his wife would be remunerated out of the profits of the farms.

As conditions in England and Wales have shown some variations two estimates of cost of labour are presented below, one for England and Wales and the other for Wales and Monmouth. In each case there have been changes in areas under cultivation as well as changes in amounts of labour used and in rates paid for labour, so that it has seemed desirable to present estimates of costs of labour on the basis of constant and of reduced areas.

In England and Wales there was steady reduction in the amounts of labour used from 1926 onwards, and accelerated reduction in the most recent period. In effect the penultimate column is a measure of the changes in the national wages bill in

agriculture while the last column is a measure of the changes in the wages bill for a fixed area, like 10,000 acres, of average farm land.

TABLE XI.

Changes in Costs of Labour. England and Wales.

Year.	Index of Amount of Labour Used.	Index of Wages and Earnings of Workers	Index of Acreage.	Index of Cost of Labour: On Reduced Acreage.	Index of Cost of Labour: On Constant Acreage.
1924	100	89	100	89	89
1925	100	100	100	100	100
1926	101	101	100	102	102
1927	99	101	99	100	101
1928	99	101	99	100	101
1929	99	101	99	100	101
1930	96	101	98	97	99
1931	93	100	98	93	95
1932	90	99	98	89	91
1933	92	97	97	89	91
1934	89	98	97	87	90
1935	87	101	97	88	90
1936	84	102	96	86	89
1937	82	105	96	86	89

In Wales, where the amount of labour used was increasing up to 1929, the cost of labour also increased and the cost did not fall below the 1925 level until 1933 when important reductions in amounts of labour and rates of payment occurred together.

TABLE XII.

Changes in Costs of Labour. Wales.

Year.	Index of Amount of Labour Used.	Index of Wages and Earnings of Workers	Index of Acreage.	Index of Cost of Labour: On Reduced Acreage.	Index of Cost of Labour: On Constant Acreage.
1924	103	95	100	98	98
1925	100	100	100	100	100
1926	103	102	99	106	106
1927	104	102	99	106	107
1928	106	101	99	107	108
1929	108	101	98	109	111
1930	106	101	98	107	109
1931	106	99	98	105	107
1932	103	99	98	102	104
1933	97	97	98	94	96
1934	91	98	97	89	91
1935	90	99	97	89	92
1936	82	100	97	82	85
1937	80	102	96	82	85

In Wales the chief factor in the increased cost of labour up to 1929 was the increase in amount of labour used, but after 1932 both changes in amount of labour used and changes in wages contributed to the reductions in costs of labour.

FIGURE 3.

Changes in National Agricultural Wages Bill.

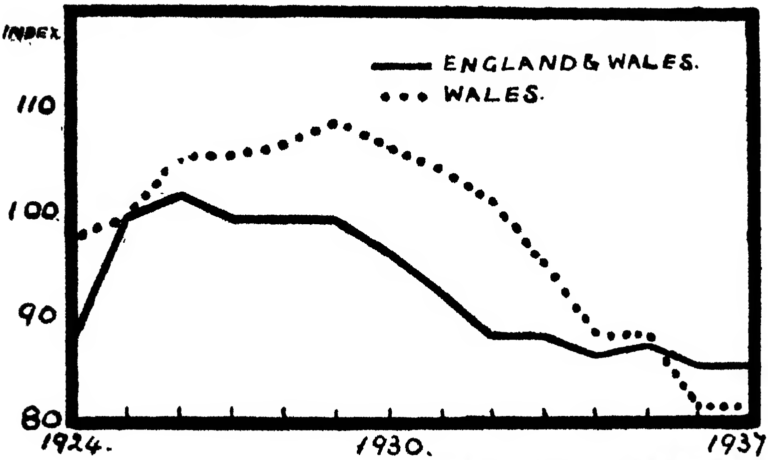
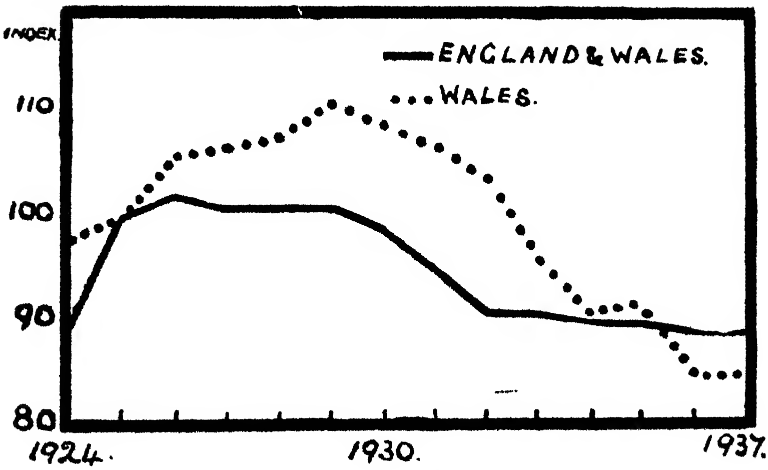


FIGURE 4.

Changes in Cost of Labour.



Unemployment.

During the whole of the period under review the number of workers engaged in agriculture in England and Wales, including relatives of farmers with hired workers, was falling. In Wales conditions varied and there was an appreciable increase in

amount of labour employed up to 1929, a slight decline in the following two years, and then a more rapid decline. In 1936 the amount of labour employed on Welsh farms was estimated to be 82 and in 1937 80 per cent. of the quantity employed in 1925. The contraction of the demand for labour was not due to any contraction in either the gross or the net output of the industry, and only to a very minor extent to the reduction of area of land by loss to building and other non-agricultural purposes, but was mainly if not wholly due to the search for economy in use of labour through fuller use of equipment, search for improved equipment, and improved organisation for labour tasks, and was partly a response to the minimum rates of wages and a necessary effort to maintain and improve standards of living in the industry. Reduction in the amount of labour was not generally due to shortage for at various times there was considerable unemployment amongst farm workers. The *Census* of 1931 showed an average of about 7-8 per cent. unemployed in England and Wales and about the same figure was found for Wales. In the early winter periods following the dry summers of subsequent years, there was a marked degree of unemployment and by 1935 it was generally recognised that agriculture like other industries had some surplus of labour under conditions then prevailing.

The Unemployment Insurance (Agriculture) Act was passed in April and came into force in May, 1936. This increased the cost of adult labour by 19s. 6d. per man each year except where the system of half-yearly hiring enables the employer to reclaim 12½ per cent. of the cost or in the case of yearly hiring 25 per cent.[4]

Of the total of 695,000 persons insured in July, 1937, against unemployment under the Agricultural scheme 28,550 or 4.1 per cent. were in Wales. The comparative proportions were as follows :—

Percentage of Insured Workers.

	Great Britain. %	*Wales.* %
Farming and Forestry	69.0	79.6
Market Gardening and Horticulture	11.4	5.4
Private Gardening	15.2	12.0
Other Gardening	4.4	3.0
	100.0	100.0

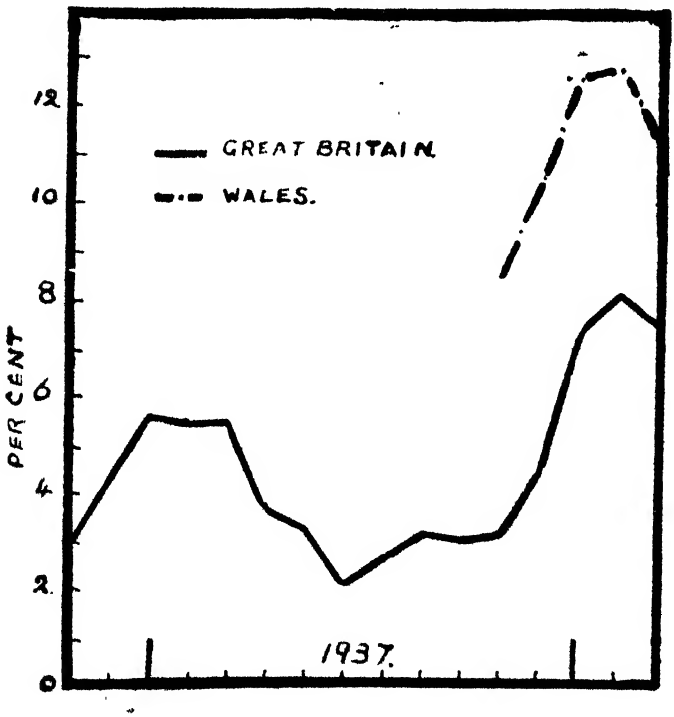
[4] These rates of payment and reclaim apply also to employees.

Farming and forestry in Wales account for a much larger proportion of the insured workpeople than is the case in Great Britain as a whole. Of all insured workers engaged in farming, forestry, market gardening and horticulture about 7 per cent. were females, but in Wales the proportion was under 4 per cent. In Wales 76 per cent. of the insured male workers were over 21 years of age and 56 per cent. of the insured female workers. These relative proportions were lower than those recorded for Great Britain.

The monthly statements of insured workers unemployed show that unemployment in agriculture and forestry was 5 per cent. in January, 1937, and fell to 2 per cent. in June. By October it had increased to 3 per cent. and then a sharp increase occurred and last January it amounted to 8.4 per cent. Unemployment amongst insured workers engaged in market gardening and horticulture fell from 8.4 per cent. in January, 1937, to 2.4 per cent. in June, had increased again to 5 per cent. in October, and by last December had increased to 12.8 per cent.

FIGURE 5.

Unemployed as a Percentage of Total Insured.



Since last October separate information is available for each of the nine areas into which Great Britain is divided. In five of these areas namely North Eastern, Northern, North Western, Scotland and Wales the percentage of unemployed has been very high. In Wales 8.5 per cent. of the insured workers were registered as unemployed in October of last year and by January it had increased to 12.7 per cent. Wales has had the highest unemployment of every month except last January when the North Western had a slightly higher rate.

Payments in Kind.

During the three years 1925-27 the reckoning of benefits or advantages as part payment of the minimum wages was prohibited in Monmouth but at the present time all the committees have fixed values for cottage rents, board and lodgings, milk and potatoes or potato ground. In addition the Committees for Carmarthen and Pembroke and Cardigan have fixed a rate of 1s. 6d. per hour for the use of a man with horse and cart or 8d. per hour for a horse and cart to do cartage. In Merioneth and Montgomery grazing land is allowed to workers at 10d. per acre per week or 43s. 4d. a year.

Changes in the values fixed for board and lodging of "adult" male workers have been made in the areas of Glamorgan, Merioneth and Montgomery, and Pembroke and Cardigan. The values fixed in Glamorgan have varied from 15s. 6d. to 17s. The variations within the eight determinations in any individual year have been between 6d. and 2s. per week.

Value of Board and Lodgings. "Adult" Males.

Area.	*Period.*	*s.*	*d.*	*Age.*
Monmouth				19 & over
Anglesey and Caernarvon ...				All ages
Carmarthen	1925-37	15	0	17 & over
Radnor and Brecon				18 & over
Denbigh and Flint	1925-37	15	6	17 & over
Merioneth and Montgomery ...	1925-32	16	0	19 & over
	1933-37	15	6	20 & over
Pembroke and Cardigan ...	1925–	12	6	18 & over
	1926–	14	6	18 & over
	1928-36	15	0	18 & over
	1937-	15	9	18 & over
Glamorgan	1925-27	17	0	18 & over
	1928-32	16	0	18 & over
	1933-	14	6	18 & over
	1934-36	15	0	18 & over
	1937—	16	0	18 & over

No provision is made by the Committee in Merioneth and Montgomery for the board and lodgings of females and the values fixed in the other areas for " adult " females have undergone no change during the period.

Value of Board and Lodgings. " Adult " Females.

Area.	*s. d.*	*Age.*
Monmouth	15 0	19 & over
Anglesey and Caernarvon ...	15 0	All ages
Carmarthen	15 0	17 & over
Radnor and Brecon	13 0	17 & over
Glamorgan	12 9	17 & over
Pembroke and Cardigan	12 6	17 & over
Denbigh and Flint	12 0	16 & over

All the Committees except that operating in Anglesey and Caernarvon fix differential values for boys of differing ages. There is a good deal of variation between the values fixed by the different committees which does not appear to be closely related to the conditions covered by the allowances. Substantial changes have occurred in the areas of Glamorgan, Pembroke and Cardigan, Radnor and Brecon, and Merioneth and Montgomery.

TABLE XIII.

Value of Board and Lodgings for Youths.

Age.	*Period*	*19—*	*18—*	*17—*	*16—*	*15—*	*14—*
		s. d.	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*
Monmouth ...	1928-37		11 0	12 0	10 0	10 0	7 0
Carmarthen ..	1925-37				13 0	13 0	13 0
Denbigh and Flint...	1925-26				13 0	13 0	13 0
Denbigh and Flint...	1927-37				13 0	11 0	11 0
Merioneth and Montgomery ...	1925-26		15 0	13 0	11 0	9 0	7 0
,,	1927-31		14 0	15 0	11 0	9 0	7 0
,,	1932-37	14 6	13 6	13 0	11 0	9 0	7 0
Radnor and Brecon	1926-31			11 0	13 0	12 0	11 0
,,	1932-			13 6	12 6	12 0	11 0
,,	1932-37			14 0	13 0	12 0	11 0
Pembroke and Cardigan ...	1925			12 0	12 0	11 6	11 0
,,	1925-28			11 0	14 0	13 6	13 0
,,	1929-36			14 0	13 0	12 0	12 0
,,	1937			14 9	13 9	12 0	12 0
Glamorgan ...	1925-27			16 0	15 0	13 0	11 6
,,	1928-31			15 0	14 0	12 3	11 0
,,	1932-33			11 0	13 0	11 3	10 0
,,	1934-37			14 6	13 6	11 9	10 6
,,	1938			15 6	14 6	12 3	11 0

Separate values of board and lodgings for girls have been fixed in only five areas. The rates fixed are :—

TABLE XIV.
Value of Board and Lodgings for Girls (Whole Period).

Age.	17—	16—	15—	14—
	s. d.	s. d.	s. d.	s. d.
Carmarthen		12 0	11 0	10 0
Denbigh and Flint			9 6	9 6
Glamorgan	12 0	11 3	9 9	8 7
Pembroke and Cardigan ..	12 0	12 0	11 6	11 0
Radnor and Brecon		12 0	11 0	10 0

In Monmouth the differential values for boys apply also to girls, in Anglesey there is only one value for all ages of males and females, and in Merioneth and Montgomery no provision is made for females.

There has been no change in any of the initial rents fixed for tied cottages. In Glamorgan the weekly rent is 4s. and in Monmouth 4s. for a cottage of five rooms or more and 3s. 6d. for one of 4 rooms or less. In the remaining six areas the weekly rental is fixed at 3s.

In four areas definite values are fixed for milk supplied to workers and in the other areas the value is the local wholesale price. The value of milk in Denbigh and Flint is 1½d. per pint in summer and 2d. in winter, but in Merioneth and Montgomery and in Radnor and Brecon 1s. per gallon in summer and 1s. 6d. in winter. In Pembroke and Cardigan the value was first fixed at 1s. per gallon in 1926; in 1927 the value of milk supplied during the winter months was increased to 1s. 5d.; but it has again been fixed at a uniform yearly level of 1s. per gallon.

Farmers in Denbigh and Flint can charge 4s. per cwt. for potatoes supplied to workers and those in Anglesey and Caernarvon the local wholesale price. Workers in Pembroke and Cardigan, in Glamorgan, and in Carmarthen, can have potato land for a charge of 5s. per 100 yards drill, and those in Monmouth, and Radnor and Brecon, for 6d. per 20 yards drill.

Conclusions.

When the Agricultural Wages (Regulation) Act came into force its immediate effect was to increase rates of wages in Wales by an average of about 5-6 per cent. After 1925 the rates were remarkably stable. There was a slight tendency to weakness in 1931 and marked weakness in 1932 and 1933, but by 1934 the

trend was reversed and considerable increases occurred up to the end of 1937. During the period 1925 to 1927 the amount of labour used was increasing, and it remained slightly higher than in 1924 until 1932. This increase in labour was partly due to the condition of the industrial labour market. Increases and decreases in labour occurred in the different counties at somewhat different times but during and after the industrial troubles of 1926 there was some return of labour to farms in Carmarthen, Cardigan, Pembroke, and Denbigh, and in the years following 1926 labour which would normally have transferred to other occupations was held back on farms by the weakness of the industrial labour market. But by the time when agricultural wage rates began to weaken in 1932, the amount of labour on farms was being reduced and unemployment of agricultural workers was common. A marked reduction in labour began in 1933 and has since continued. During 1936 and 1937 there was quite strong attraction of agricultural workers by other forms of employment. Doubtless the reduction in supply of labour on offer affected the recent determinations of rates of wages.

The system of regulation of wages undoubtedly assisted the workers to improve their positions at the beginning of the period and almost certainly to safeguard them during the depression. On the other hand it did not deprive the farms of labour and may in fact have assisted in maintaining a supply. The recent increases in rates do not appear to have been sufficient to retain quite the full amount of the previous supply of labour, but there is also a probability that the labour requirements of given combinations of arable and pasture land and livestock are slowly being reduced. While wages rose about 5-6 per cent. from 1924 to 1925 the amount of labour used seems to have fallen a little so that cost of labour also showed decline. Then a new set of conditions arose, labour flowed to the farms while rates of wages were firm and cost of labour, including that of the labour of farmers' relatives, rose 6 per cent. in 1926 and 11 per cent. in 1929. But practically all this increase was due to a rise in the ratio of labour to land. In 1930-31 the trends turned, and there is now nearly 20 per cent. less labour on the land, while labour costs are 15 per cent. below those of 1925, although rates of wages stand at about the same figure. The chief changes in rates of wages were those which occurred immediately after the Act came into force, but the chief changes in amounts of labour have occurred since 1932. A new set of conditions has recently arisen

in the industry and it appears that fresh changes in either rates of wages or in organisation for the accomplishment of labour tasks are imminent. In England, on the other hand, apart from a little increase in the amount of labour in 1926 and again in 1933, the amount of labour used has been falling. Wages showed much larger increases than in Wales during the early period of regulation, about the same decline in the worst part of the depression, and have since shown more rapid increase. Cost of labour rose about 11-12 per cent. between 1924 and 1926, and was then nearly steady, but showed fairly sharp decline after 1929. The cost of labour shows less reduction than in Wales because of the recent greater rise in rates of wages. In both England and Wales there has been substantial decrease in the agricultural labour bill while farm workers have been improving their economic position.

APPENDIX.

Current minimum weekly wages—"Ordinary" youths under 21 years.

Area.	*20 and under 21.*		*19 and under 20.*		*18 and under 19.*		*17 and under 18.*		*16 and under 17.*		*15 and under 16.*		*14 and under 15.*	
	s.	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*
Monmouth	33	0	29	6	26	6	22	0	17	6	11	6	11	0
Anglesey and Caernarvon ...	28	6	26	6	23	6	20	c	18	0	18	0		
Carmarthen ...	29	6	27	6	25	0	23	0	20	0	18	6	17	0
Denbigh and Flint ..	27	6	25	0	22	6	18	0	14	0	11	6		
Glamorgan ..	32	0	30	0	27	0	24	6	20	6	18	0	16	0
Pembroke and Cardigan ..	30	6	28	0	25	6	23	0	20	6	18	0	15	6
Merioneth and Montgomery ...	31	6	28	4	25	3	21	0	17	10	14	9	11	6
Radnor and Brecon ...	28	4	26	6	23	7	20	1	17	8	14	9	12	5

RECENT FINANCIAL RESULTS OF DIFFERENT TYPES OF FARMS IN WALES (1935-36) AND (1936-37).

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Accounts for two consecutive years (1935-36 and 1936-37) are available for the same 57 farms. These have been divided into type groups which are fairly representative of general farming conditions in Wales and the financial and economic data are briefly summarised in this article. It is fully realised that the number of records is small but at the same time it is felt that the results for the type-groups are sufficiently representative to indicate fairly closely the fortunes of farms of similar types and in similar situations to those here defined and that they at any rate give a broad indication of the state of farming for the farm types in Wales as a whole.

The area for each group remains the same in both years—the only changes being those in internal management and financial results. The total area covered by these farms together with the rent per farm and per acre is stated in Table I.

TABLE I.

Total Acres, Average Size of Farm and Rentals.

Farm-type.	*Cattle & Sheep. (Poor Land).*		*Cattle & Sheep. (Better Land).*		*Mixed Farms.*		*Cattle & Milk.*	
Year.	*1935-6*	*1936-7*	*1935-6*	*1936-7*	*1935-6*	*1936-7*	*1935-6*	*1936-7*
No. of Farms	10	10	12	12	10	10	25	25
Total Acres	2,648	2,648	2,520	2,520	1,007	1,007	2,988	2,988
Average size of Farm (acres)	265	265	210	210	101	101	120	120
Rent per Farm	£99.0	£98.5	£188.3	£185.5	£128.6	£127.7	£146.8	£149.4
Rent per Acre	7s. 6d.	7s. 5d.	17s. 11d.	17s. 8d.	25s. 6d.	25s. 4d.	24s. 7d.	25s. 0d.

Description of Type-Groups.

Cattle and Sheep Farms (Poor Land). The characteristic feature of this group is that it embraces land of poor quality at fairly high elevation. The farms range in size from 105 to 764 acres. Of the 10 farms 5 are below 200 acres and 4 fall between the 200 and 350 acre size group. Rentals on the whole are low and average about 7s. 6d. per acre with variations of between

2s. 9d. and 12s. 8d. per acre. The main source of income is the sale of store cattle and sheep. Calf rearing is usually combined with butter-making but there is some liquid milk sold. The proportion of hired labour employed is small and in the majority of cases the farm is run entirely by family labour. Practically all the crops are grown for the maintenance of live stock and the sale of crops on these farms is almost negligible.

Cattle and Sheep Farms (Better Land). This type represents land of better quality. The stocking is more intensive and the holding is of a smaller type. While the average size is 210 acres, the range is from 61 to 486 acres but half the farms are below 150 acres in size. The rents range from 11s. 8d. to 31s. 8d. per acre with an average rental of about 18s. 0d. per acre. Receipts are mainly derived from the sale of cattle and sheep (both fat and store) but pigs and poultry are also sources of income. Some butter is sold, but the production of liquid milk for sale appears to be of growing importance. Potatoes and cereals constitute the major part of the crops sold but crop sales are of minor importance. Of the total persons employed (including the occupier and his wife) about 57 per cent. is hired labour.

Mixed Farms. As regards size the mixed farms group average slightly over 100 acres with variations between 30 and 296 acres. Six of the 10 farms are under 100 acres in size. Rentals range from 12s. 3d. to 45s. 5d. per acre and average about 25s. 5d. per acre. More prominence is given to the cultivation of arable crops than on the other type-groups and sale of cash crops is of greater importance. This group is also characterised by a much higher output of pigs and poultry and eggs and sales of liquid milk. About 59 per cent of the total labour (including the occupier and his wife) is hired.

Cattle and Milk Farms. For this group the farms range in size from 17¾ acres to 335 acres with a general average of 120 acres. Fourteen of the 25 farms are below 100 acres in size. Rents show considerable variations and range from 9s. 8d. per acre to 66s. 2d. per acre. The majority of the farms have rentals of over 20s. per acre and the average for the group is about 25s. 0d. per acre. While the sale of liquid milk is of major importance, receipts from cattle and pigs and to a lesser extent sheep form important sources of revenue. The proportion of hired labour to total persons engaged is higher than for any other of the farm-type groups.

Land Utilisation.

As the bases of classification into groups are differences in type of farming, it is to be expected that the use made of the land is an important aspect of any discussion of differences in farm organisation. Sale of crops is not an important source of revenue for any of the farm-types, but the receipts from crops is definitely of more importance on the Mixed and Cattle and Milk farms than on the Cattle and Sheep (Poor and Better Land) groups. But it has to be borne in mind that while two groups may show similar acreages of certain crops grown there may be marked differences in the method of disposal of the crops. Because of differences in size, percentage figures provide the best basis of land utilisation for the farm types and these are stated in Table VI. The proportion of arable land is not very high for any of the farm types and even for the Mixed farms which have the highest percentage of land under the plough, the arable area did not exceed 12½ per cent. of the total area. In the other three groups the differences in arable are not so very great and the area does not reach 11 per cent. in any one group.

The high proportion of rough grazing (nearly 60 per cent.) for the Cattle and Sheep (Poor Land) group is consistent with the general situation of this type of farm. It is also noticeable that the proportion of rough grazing declines and that the area devoted to hay increases from the Cattle and Sheep (Poor Land) to the Cattle and Milk Farms and reflects the general importance of the livestock enterprises for the different groups. There are significant variations between the farm-types in the crops grown. Oats are the most important cereal crops in all groups and represent roughly from 38 to 49 per cent. of the arable area. Wheat is largely confined to the Cattle and Sheep (Better Land) and Mixed farms but a fair proportion of the arable land is occupied by the crop on the Cattle and Milk farms. Barley is definitely of greater importance on the Mixed farms and more prominence is given to potatoes on the Cattle and Milk farms. The percentage of arable land under turnips and swedes, and mangolds, is small on the Cattle and Sheep (Poor Land) farms but more prominence is given to the cultivation of rape and kale (mainly rape) than in the case of the other groups.

The ways in which farmers have changed their practice in response to changing conditions can best be seen by comparing the practice in each of the two years for the different farm-types. In all the groups except the Cattle and Milk farms there is a

slight reduction in arable area and this indicates a continuance of the tendency to lay down cropping land to grass. There has been a reduction in the acreage of wheat and barley in all the groups. In the consideration of the oat crop the acreage under mixed corn has to be borne in mind and taking the two crops together the cropping data indicates a decline in acreage for the Cattle and Sheep (Poor and Better Land) and a slight increase for the Mixed and Cattle and Milk farms. Apart from the Mixed farms, there has been a reduction in the acreage under potatoes but the Cattle and Milk farms show the same acreage in both years. Turnips and swedes have declined in area and mangolds show an increase and this change is probably connected with an increase in the number of dairy cows. Except on the Cattle and Sheep (Better Land) and the Cattle and Milk farms the area under rape and kale has declined. The proportion of farm land used for hay has increased in all the groups except the Cattle and Milk farms.

Livestock Carried.

The different kinds of livestock carried and the variation in their use and management are reflections of the type of farming in each group. In comparison with other groups the Cattle and Sheep (Poor and Better Land) groups carry a larger sheep population, a lower head of cattle and a considerably lower number of pigs and poultry per 100 acres. On the same comparative basis, while the Mixed farms carry a larger head of cattle the Cattle and Milk farms carry more dairy cows. Both in pigs and poultry the Mixed farms carry a much larger head of stock than any of the farm-type groups. Details of the livestock carried per farm is given in Table VII. A comparison of the records for the two years reveals a few interesting though small changes. Apart from the Cattle and Sheep (Poor Land) group there has been a slight increase in the number of horses other than "Work" horses. Total cattle, except on the Cattle and Milk farms have increased and number of dairy cows for all groups except the Cattle and Sheep (Better Land) group. There has been a tendency to increase the ewe flock on the Cattle and Sheep (Poor and Better Land) and a decline in number is noticeable on the other farm-types. Breeding sows and other pigs have declined in number on the Cattle and Sheep (Poor Land) and the Cattle and Milk Farms while the reverse is true in the case of the other two groups. Contrary to expectations the poultry flocks have increased on the Cattle and Sheep (Poor and Better Land) and declined in number on the Mixed and Cattle and Milk farms,

Number of Persons employed per Farm.

The average composition of the farm personnel in various farm-type groups is shown in Table II. Family labour includes the work of the farmer and his wife and all other members of the family who participate in the work of the farm. The amount of casual labour employed on these farms is small and is included in the statement given for hired labour. It is clear that there is a different emphasis upon the use of family labour particularly as between the Cattle and Sheep (Poor Land) and the other farm-types The proportion of female labour is also higher on this group and represents roughly about one-fourth of the number of persons employed. Other groups show a female labour in the proportion of roughly one-fifth or one-sixth of total labour employed. The greater number of the hired workers employed are boarded in the farm house, though in all the four groups there is a small proportion who live in farm cottages or in houses conveniently situated to the farms where they are employed.

TABLE II.
Number of Persons Employed (per Farm).

Farm-type.	*Cattle & Sheep (Poor Land).*		*Cattle & Sheep (Better Land).*		*Mixed Farms.*		*Cattle & Milk.*	
Year.	*1935-6*	*1936-7*	*1935-6*	*1936-7*	*1935-6*	*1936-7*	*1935-6*	*1936-7*
	No.	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*
Farmer and Wife ...	0.9	0.8	0.6	0.6	0.9	0.9	0.8	0.8
Other Family Labour ...	1.0	1.0	0.9	1.1	0.4	0.5	0.4	0.4
Total Family ...	1.9	1.8	1.5	1.7	1.3	1.4	1.2	1.2
Hired labour ...	1.0	1.1	2.1	2.0	1.7	1.7	2.1	2.1
Total persons inc. Farmer and Wife ...	2.9	2.9	3.6	3.7	8.0	3.1	3.3	3.3
Total persons exc. Farmer and Wife ...	2.0	2.1	3.0	3.1	2.1	2.2	2.5	2.5
Total persons inc. Farmer and Wife per 100 acres ...	1.1	1.1	1.7	1.8	3.0	3.0	2.8	2.8

The average number of hired workers employed per farm is greatest on the Cattle and Sheep (Better Land) and Cattle and Milk farms where the recorded average is slightly over 2 workers per farm. On the Cattle and Sheep (Poor Land) the average is only one worker per farm.

There is very little change in any of the farm types as regards total number of persons employed or in the average

composition of the farm personnel for the two years. Expressed per 100 acres of land, the greatest amount of employment is provided by the Mixed farms (3 persons) and the least by the Cattle and Sheep (Poor Land) with 1.1 persons per 100 acres.

Capital Invested

The investment per farm in live and dead stock on the basis of the average of the opening and closing valuation is set out in Table VIII. The figures indicate that the average tenant's investment in these forms for working the Cattle and Sheep (Poor Land) farms is from £3 to £4 per acre, for the Cattle and Sheep (Better Land) from £6 to £7 per acre, for the Mixed farms from £12 to £18 per acre, and for the Cattle and Milk farms from £10 to £11 per acre. For all the farm-types the greater proportion of the capital is invested in livestock, with emphasis on cattle. Other interesting facts which emerge from the records are the high capital investment in pigs on the Mixed farms, the low capital investment in pigs and poultry on the Cattle and Sheep (Poor and Better Land) groups together with a high capital investment in sheep as compared with the other groups.

There are no outstanding changes in the two years in the distribution of the capital invested except that the capital invested in horses, cattle and sheep has increased for all farm types. This is due partly to increase in numbers and partly to improvement in prices. Apart from the Cattle and Sheep (Better Land) group there is a decline in the capital invested in pigs and poultry. Capital in crops, owing to smaller supplies, shows a decline for all farm-types while on account of purchases made the capital invested in implements has increased in the case of the Mixed and the Cattle and Milk farms.

Receipts.

The average gross receipts per farm for each farm-type is given in Table IX. The receipts include the value of farm produce consumed in the house on the basis of quantities and the prices realisable by sale of similar produce. The total value of farm produce consumed is in addition, stated separately. Included also in receipts is the rent of the farm house at rateable value. Receipts for cattle and wheat are inclusive of subsidy payments The gross receipts are influenced by changes in the type and quantity of the produce sold together with changes in unit prices. Each of these factors has no doubt been responsible to a greater or lesser degree for the variations shown in the

receipts as between 1935-36 and 1936-37. Over all the farms there has been an increase of nearly £41 per farm (about 4 per cent.) in 1936-37. The improvement has been greatest on the Cattle and Sheep (Poor Land) group where it amounts to nearly 11 per cent. and least on the Cattle and Milk farms where there is practically no change.

Over all the farms most of the items comprising the gross receipts show some increase. The exceptions being cream and poultry with a decline each of about 9 per cent., and crops and sundries with drops of about 16 per cent. and about 28 per cent. respectively. The increase of 11 per cent. in the income from cattle is due to various causes—an improvement in prices, the cattle subsidy and a larger head of cattle sold. It might have been expected that as a result of more dairy cows there would have been a substantial rise in the receipts from milk. One possible explanation of this is that in the Cattle and Milk farms where the sale of milk is of major importance there was a reduction in the yield per cow. The increase of 9 per cent. in the income from pigs is due partly to an increase in the numbers sold and partly to a rise in prices while the decline in the income from poultry is mainly due to a reduction in the flocks. The high returns from sheep and horses can be attributed to a rise in prices, while the contraction of the arable area is one of the factors responsible for the decline in the income from crops.

An examination of the gross receipts in Table IX throws further light on the organisation of the different types of farms and the data indicates the importance of sales of cattle and sheep on the Cattle and Sheep (Poor and Better Land) groups, of pigs on the Mixed farms and milk on the Cattle and Milk farms. Improved prices for most commodities together with some internal changes in organisation have caused larger receipts in all groups than in 1935-36, particularly is this noticeable in the income from cattle. With the exception of the Mixed farms the sales of sheep have also increased while in the case of pigs the only group that shows a decline in receipts is the Cattle and Sheep (Poor Land) type and this is also the only group that shows a higher income from poultry. Sales of milk provided slightly larger receipts from all groups except the Cattle and Milk farms. All farm-types show a decline in the receipts from crops and this is particularly noticeable in the case of cereals and garden produce. In the case of roots and potatoes there was an increase in sales for all groups except the Cattle and Sheep (Poor Land) farms.

Expenses.

Details of the average expenses per farm in each farm-type are given in Table X. Over all the farms taken together there is a rise of 3 per cent. in total expenses and the variation is from a reduction of 3 per cent. on the Mixed farms to an increase of over 15 per cent. on the Cattle and Sheep (Better Land). In terms of £ per farm the variation is from a reduction of £40 per farm on the Mixed farms to an increase of £70 per farm on the Cattle and Sheep (Better Land) group.

Rent and rates remain at about the same figure in both years and there is only a rise of slightly over 1 per cent. in labour costs. Expenditure on feedingstuffs has risen by 14 per cent., partly due to higher unit costs and partly to the purchase of larger quantities. There is a reduction in the expenditure on manures (about $1\frac{1}{4}$ per cent.) and on seeds (about 8 per cent.) but there has been a very considerable increase in purchase of implements and machinery (58 per cent.) partly for saving labour. Expenses incurred on purchase of total livestock were lower by about 1 per cent. in 1936-37, but purchases of cattle and pigs had increased by about 2 per cent. and sheep by over 6 per cent. There was, on the other hand, a considerable reduction in the expenditure on horses and poultry. As might be expected changes in items of expenditure vary considerably from one farm-type to another. In all the groups the cost of labour has remained practically unchanged except for the Mixed farms group where there is a rise of nearly 4 per cent. There has been a general increase in the cost of feedingstuffs but this increase is more prominent on the Cattle and Sheep (Poor and Better Land) groups where the rise is 57 and 30 per cent. respectively. Expenditure on fertilisers has risen substantially on the Cattle and Sheep (Better Land) group (62 per cent.) and a quantitative increase is the main cause. The Mixed farms and the Cattle and Milk farms show a considerably lower expenditure on fertilisers in 1936-37. Apart from the Cattle and Sheep (Poor Land) group there has been a rise in the expenditure on implements and machinery and in particular on the Mixed and Cattle and Sheep (Better Land) farms. Fewer horses were bought in 1936-37 and expenditures on horses were lower for all farm-types. Only on two groups were the purchases of cattle higher—the Cattle and Sheep (Poor Land) [18 per cent.] and the Cattle and Sheep (Better Land) [54 per cent.]. In the case of sheep there was a rise in expenditure on the Cattle and Milk farms while on

the other farm-types expenses were lower than in 1935-36. Purchase of pigs is only a heavy item on the Mixed farms and here the increase in expenditure between 1935-36 and 1936-37 was about 11 per cent. There was also an increase in expenditure on pigs on the Cattle and Sheep (Better Land) group but here purchases of pigs represent a small item—the figures being £6 per farm in 1935-36 and £9.2 per farm in 1936-37. Apart from the Cattle and Sheep (Better Land) group there appears to have been a decline in the expenditure on poultry.

Financial Results.

The farmers' profit (Farm Income) as set out in Table III represents the balance between receipts and expenses after allowing for any difference in the opening and closing valuations. In the case of farms occupied by owners, the rent is assessed by the Department, after consultation with the farmer concerned, and in relation to rents of similar farms actually rented. No charge is made in the labour costs for the farmers' own time as

TABLE III.

Farm Income in £ per Farm.

Year.	*Receipts.* £	*Expenses.* £	*Cash Balance.* £	*Valuation Difference.* £	*Farm Income.* £
		Cattle and Sheep (Poor Land)			
1935-6	572.3	464.5	107.8	+ 46.8	154.6
1936-7	634.1	476.4	157.7	— 4.4	153.3
		Cattle and Sheep (Better Land).			
1935-6	1,071.6	953.0	118.6	+ 50.7	169.3
1936-7	1,172.0	1,100.1	71.9	+ 68.0	139.9
		Mixed Farms.			
1935-6	1,412.0	1,343.6	68.4	+ 76.1	144.8
1936-7	1,458.5	1,302.6	155.9	+ 67.4	223.3
		Cattle and Milk Farms.			
1935-6	1,220.7	1,033.3	187.4	+ 75.2	262.6
1936-7	1,222.2	1,034.6	187.6	+ 32.6	220.2

worker or manager or any manual labour done by his wife. Labour of relatives (mainly sons and daughters) is charged in expenses, at prevailing rates of wages for employees on the basis of the time worked. The amount charged for hired labour includes the value of produce allowed to workers as perquisites and of cottage accommodation or board given in lieu of cash wages. The receipts include the value of the farm produce consumed in the house and the rent of the farm house at rateable value. The profit as stated must therefore be taken to represent

the reward of the occupier (the farmer and his wife) for work and management and also for the use of the capital which is invested in the farm.

Over all farms the balance of receipts over expenses is £80 more per farm, but owing to smaller increases in valuation the farm income is £11 less per farm than in 1935-36. Apart from the Cattle and Sheep (Better Land) group (where the expenses on feedingstuffs, manures, implements and purchases of cattle show an appreciable increase), the position as regards surplus of receipts over expenses has improved for all the farm-types and in particular for the Mixed farms. When, however, the valuation differences are considered, all farm types with the exception of the Mixed farms show a decline in farm income. The decline being highest on the Cattle and Milk farms (£42.4 per farm) and least on the Cattle and Sheep (Poor Land) group £1.3 per farm).

The number of profits and losses for each farm-type is given in Table IV.

TABLE IV.

Profits and Losses by Type-Groups.

	1935-6.			*1936-7.*		
	Losses.	*Profits.*	*Total.*	*Losses.*	*Profits.*	*Total.*
Cattle and Sheep (Poor Land) ...	1	9	10	1	9	10
Cattle and Sheep (Better Land) ...	3	9	12	2	10	12
Mixed Farms ...	4	6	10	1	9	10
Cattle and Milk ...	4	21	25	4	21	25
All Farms ...	12	45	57	8	49	57

Over all farms there is a decrease in the number of losses in 1936-37. The position remains unchanged on the Cattle and Sheep (Poor Land) and the Cattle and Milk farms.

As previously stated the farm income is the amount available to remunerate the farmer for his own capital investment, for his labour as manager and for any manual work done by the occupier and his wife. As it is reasonable to expect that the "farm income" should provide a fair return on the capital investment, and wages at least at Wages Board rates to the occupier and his wife for their manual labour; it may be of interest to try and arrive at a measure of the reward for management of the different farm-types. This is done by deducting from the farm income a figure representing interest on the capital invested and wages for the work of the farmer and his wife.

This has been done by allowing an interest charge of 6 per cent. per annum on the total farm investment[1] and while no special claims for accuracy for this rate are made it can be claimed that farming is a speculative industry and that capital should be remunerated at the rate of 6 per cent. The basis adopted for wages is to assess the full-time manual labour of an occupier at £80 per annum and a wife at £52 per annum.

Table V shows in addition to the farm income, the sums involved for occupier's wages and interest on capital and the results on a further basis of "labour income" and "management earnings." The "labour income" is "farm income" minus allowance for interest on capital at the rate of 6 per cent. per annum and therefore represents the earnings of the farmer and his wife in manual labour and management on the farm. The "management earnings" is the sum left over after deducting from the "labour income" wages to the farmer and his wife for manual labour.

TABLE V.

Farm Income, Labour Income and Managerial Earnings in £ per Farm.

Farm-Type	*Farm Income.*		*Interest on Capital at 6 per cent.*		*Labour Income.*		*Allowance for Wages to Farmer and Wife.*		*Managerial Earnings.*	
Year.	1935-36	1936-37	1935-36	1936-37	1935-36	1936-37	1935-36	1936-37	1935-36	1936-37
	£	£	£	£	£	£	£	£	£	£
Cattle & Sheep (Poor Land)	154.6	153.3	61.6	62.8	93.0	90.5	66.7	61.4	26.3	29.1
Cattle & Sheep (Better Land)	169.3	139.9	87.0	90.5	82.3	49.1	50.4	46.9	31.9	2.5
Mixed Farms	144.8	223.3	76.5	80.7	68.3	142.6	64.8	66.1	3.5	76.5
Cattle & Milk	262.6	220.2	74.2	77.4	188.4	142.8	63.7	59.2	124.7	83.6

When interest is allowed on capital at 6 per cent. per annum the "labour income" per farm in the Cattle and Sheep (Poor Land) group was 35s. 9d. per week in 1935-36 and 34s. 9d. per week in 1936-37, in the Cattle and Sheep (Better Land) group it averaged 31s. 7d. per week in 1935-36 and 58s. 0d. per week in 1936-37, in the Mixed farms the "labour income" averaged 26s. 3d. per week in 1935-36 and 54s. 10d. in 1936-37 and on the Cattle and Milk farms the average "labour income" was 72s. 5d. in 1935-36 and 54s. 11d. per week in 1936-37. From the figures it will be seen that there was a decrease in the "labour income" for all farm-types in 1936-37 apart from the Mixed farms.

[1] As previously described, p. 36.

When wages are allowed for manual work done by the farmer and/or his wife at the rate of £80 and £52 per annum respectivyely for actual time worked it will be noticeable (Table V) that with the exception of the Cattle and Sheep (Poor Land) and the Mixed farms the " management earnings " have declined in 1936-37 for the other farm-types. For the Cattle and Sheep (Poor Land) they averaged 10s. 1d. per week in 1935-36 and 11s. 2d. per week in 1936-37; on the Cattle and Sheep (Better Land) the " management earnings " were 12s. 3d. in 1935-36 and 11d. per week in 1936-37, on the Mixed farms they were 1s. 4d. in 1935-36 and 29s. 5d. per week in 1936-37 and on the Cattle and Milk average " management earnings " were 48s. 9d. per week in 1935-36 and 32s. 2d. in 1936-37. Whether the test applied is " farm income," " labour income " or " managerial earnings " the results indicate that the economic position of farm-types (except the Mixed farms) shows no improvement in 1936-37. On the basis of gross receipts the output was greater and this was partly due to a general improvement in price of practically all farm commodities. On the other hand expenditure has increased for all the farm-types (except the Mixed farms) but all farm-types with the exception of the Cattle and Sheep (Better Land) group show a more favourable " cash " balance than in 1935-36. Owing, however, to smaller increases in valuation there is a decline in the " farm income " for all the groups except the Mixed farms. While it is impossible to disentangle all the factors that have led to the results indicated it can be pointed out that there has been an increase in the price of a few items of cost; that the reduction in arable land has possibly meant a greater reliance on bought feedingstuffs and that the purchases of requirements have been heavy on some of the farm-types, particularly as regards purchases of feedingstuffs and new implements. The position regarding the " farm income " remains very much the same in both years on the Cattle and Sheep (Poor Land). With a higher output and a lower expenditure the position on the Mixed farms has improved considerably in 1936-37. The Cattle and Milk farms have maintained output and expenditure at about the same level in both years but owing to a smaller increase in valuation the " farm income " has declined in 1936-37. In the case of the Cattle and Sheep (Better Land) group the output and valuation difference is higher but owing to the fact that expenses have increased appreciably there is a decline in the " farm income " in 1936-37.

TABLE VI.

Arable Land, Hay and Pasture per 100 Acres.

Farm-Type.	*Cattle & Sheep. (Poor Land).*		*Cattle & Sheep. (Better Land).*		*Mixed Farms.*		*Cattle & Milk.*	
Year.	*1935-6*	*1936-7*	*1935-6*	*1936-7*	*1935-6*	*1936-7*	*1935-6*	*1936-7*
Crops.	*Acres*	*Acres.*	*Acres*	*Acres.*	*Acres*	*Acres.*	*Acres*	*Acres.*
Corn ...	6.44	5.60	7.74	6.33	10.11	8.74	6.86	7.15
Other crops ...	2.86	2.44	2.93	2.95	2.25	2.53	2.34	2.45
Total arable ...	9.30	8.04	10.67	9.28	12.36	11.27	9.20	9.60
Hay ...	10.16	10.63	17.56	18.40	21.51	21.91	27.71	27.00
Pasture ...	21.10	21.89	45.35	45.90	49.25	49.94	54.57	55.42
Rough grazing	59.44	59.44	26.42	26.42	16.88	16.88	8.52	7.98
Total pasture	90.70	91.96	89.33	90.72	87.64	88.73	90.80	90.40
Total ...	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

TABLE VII.

Average Number of Livestock (per Farm).

Farm-type.	*Cattle & Sheep (Poor Land).*		*Cattle & Sheep (Better Land).*		*Mixed Farms.*		*Cattle and Milk.*	
Year.	1935-6	1936-7	1935-6	1936-7	1935-6	1986-7	1935-6	1936-7
	No.	*No.*	*No.*	*No.*	*No.*	*No*	*No.*	*No.*
Work Horses ...	2.5	2.7	3.4	3.2	2.6	2.6	3.1	3.2
Other Horses ...	1.5	1.3	3.2	3.6	0.5	1.0	1.9	2.1
Total Horses ...	4.0	4.0	6.6	6.8	3.1	3.6	5.0	5.3
Dairy Cows ...	8.7	9.1	9.5	9.2	13.0	13.7	19.2	19.6
Other Cattle ..	23.3	23.7	33.2	34.9	24.0	24.5	20.4	19.8
Total Cattle ...	32.0	32.8	42.7	44.1	37.0	38.2	39.6	39.4
Breeding Ewes ...	159.4	167.2	131.2	135.0	57.0	52.9	42.2	41.6
Other Sheep ...	96.0	90.1	101.0	103.4	39.5	41.2	24.0	23.4
Total Sheep ...	255.4	257.3	232.2	238.4	96.5	94.1	66.2	65.0
Breeding Sows ...	2.0	1.8	2.7	3.5	2.9	2.9	2.9	2.6
Other Pigs ...	7.4	6.7	9.8	11 5	48.8	49.0	18.7	16.9
Total Pigs ...	9.4	8.5	12.5	15.0	51 7	51.9	21.6	19.5
Laying Flock ...	51.6	52.8	102.6	94.9	210.9	190.5	93.9	78.8
Other Poultry ..	28.0	35.1	66.6	88.4	167.9	152.0	52.7	61.9
Total Poultry ...	79.6	87.9	169.2	183.3	378.8	342.5	146.6	140.7
Total Animal Units (Cows) ...	58.2	57.0	63.0	63.4	52.2	52.0	48.7	47.4
Total Animal Units (Cows) per 100 Acres	21.9	21.5	30.0	30.2	51.8	51.7	41.7	39.6

TABLE VIII.

Capital per Farm.

Farm-type.	*Cattle & Sheep (Poor Land).*		*Cattle & Sheep (Better Land).*		*Mixed Farms.*		*Cattle and Milk.*	
Year.	1935-6	1936-7	1935-6	1936-7	1935-6	1936-7	1935-6	1936-7
	£	£	£	£	£	£	£	£
Horses ...	103.0	107.1	178.8	177.3	87.9	109.2	106.7	116.6
Cattle ...	335.4	359.5	488.7	515.9	471.1	524.8	525.2	551.9
Sheep ...	293.6	301.2	337.7	372.1	156.1	175.8	94.1	98.6
Pigs ...	19.5	13.5	30.1	30.7	153.7	143.6	49.4	49.3
Poultry ...	13.1	13.0	22.5	25.9	76.1	69.2	35.8	22.3
Total Livestock	764.6	794.3	1052.8	1121.9	915.2	1022.6	801.2	838.7
Crops and Cultivation ...	130.0	127.7	152.0	149.3	71.3	69.6	139.9	146.8
Implements ...	128.5	122.3	236.6	228.7	234.8	246.0	285.9	297.8
Other Items ...	4.2	4.2	8.8	9.7	23.9	8.9	5.8	5.9
Total Capital ...	1027.3	1048.5	1450.2	1509.6	1275.2	1347.1	1232.8	1289.2
Capital per 100 Acres ...	887.9	895.9	690.4	718.8	1266.6	1338.2	1031.6	1078.7

TABLE IX.

Receipts per Farm.

Farm-type.	*Cattle & Sheep (Poor Land).*		*Cattle & Sheep (Better Land).*		*Mixed Farms.*		*Cattle and Milk.*	
Year.	1935-6	1936-7	1935-6	1936-7	1935-6	1936-7	1935-6	1936-7
	£	£	£	£	£	£	£	£
Cattle ...	176.1	194.4	426.4	469.7	207.3	289.0	234.0	240.9
Milk ...	40.1	49.1	44.0	53.8	218.2	233.7	551.2	543.1
Butter ...	34.6	36.4	18.4	16.5	9.3	9.6	0.8	1.3
Cheese and Cream ...	3.6	3.6	0.8	--	1.8	2.3	0.6	0.5
Total Dairy Produce ...	78.3	89.1	63.2	70.3	229.3	245.6	552.6	511.9
Sheep and Wool	179.5	202.9	337.5	376.2	182.6	148.7	111.1	128.6
Pigs ...	58.1	55.6	58.1	79.1	519.0	559.7	140.9	151.6
Poultry and Eggs	31.8	42.1	69.1	65.4	170.1	142.4	72.6	64.6
Horses ...	28.8	38.1	40.2	53.6	12.1	14.8	33.3	26.3
Total Livestock and Livestock Products ...	552.6	617.2	994.5	1114.3	1320.4	1400.2	1144.5	1151.9
Cereals ...	0.9	0.8	29.9	11.5	28.7	19.9	23.0	17.9
Hay and Straw ...	—	—	1.6	0.2	0.1	7.4	8.8	6.9
Roots and Potatoes	4.3	3.5	15.1	19.3	2.1	4.6	11.3	17.0
Garden Produce	—	—	3.5	1.5	3.6	—	2.9	0.5
Total Crops ..	5.2	3.8	50.1	35.5	37.5	31.9	46.0	42.3
Sundries ...	14.5	13.1	27.0	22.2	54.1	26.4	30.2	28.0
Total Receipts ...	572.3	631.1	1071.6	1172.0	1412.0	1458.5	1220.7	1222.2
Total Receipts per 100 Acres ...	216.2	239.4	510.1	558.1	1420.6	1448.9	1021.4	1022.7
Produce consumed (already inc. in Receipts) per Farm ...	46.8	46.1	34.6	35.2	27.2	24.6	28.7	27.7
Do. per 100 Acres	17.7	17.4	16.5	16.8	27.0	24.4	24.1	28.2

TABLE X.

Expenses per Farm.

Farm-type.	*Cattle & Sheep (Poor Land).*		*Cattle & Sheep (Better Land).*		*Mixed Farms.*		*Cattle and Milk.*	
Year.	1935-6	1936-7	1935-6	1936-7	1935-6	1936-7	1935-6	1936-7
	£	£	£	£	£	£	£	£
Rent ...	99.0	98.5	188.3	185.5	128.6	127.7	146.4	149.4
Rates ...	4.2	4.9	7.9	7.2	5.8	5.0	8.0	8.5
Wages (Hired) ...	77.1	77.7	171.5	168.1	135.2	136.8	164.5	162.2
Wages (Family)	75.7	75.6	65.8	72.1	26.5	31.3	29.2	33.0
Total Labour ...	152.8	153.3	237.3	240.2	161.7	168.1	193.7	195.2
Feedingstuffs ...	49.8	78.3	139.8	182.5	128.2	493.2	266.1	282.8
Manures ...	14.1	14.2	11.6	18.8	9.7	7.1	18.7	15.8
Seeds ...	10.9	7.9	13.4	10.7	5.9	7.8	8.1	8.1
Implements ...	5.9	5.0	8.8	22.7	13.8	46.0	37.8	47.8
Sundries ...	32.2	22.9	71.8	85.0	139.9	63.0	124.2	110.1
Total Direct Expenses ...	369.1	385.1	678.9	752.6	893.6	917.9	803.4	817.7
Horses ...	15.3	10.8	11.6	6.0	28.0	22.1	22.9	8.5
Cattle ...	48.3	54.7	139.8	216.0	156.8	126.1	149.8	131.0
Sheep ...	27.5	25.0	114.6	114.2	84.9	43.8	28.8	54.8
Pigs ...	3.7	0.6	6.0	9.2	168.4	187.3	25.2	19.5
Poultry ...	0.6	0.2	1.9	2.1	11.9	5.4	3.2	3.1
Total Livestock ...	95.4	91.3	274.1	347.5	450.0	381.7	229.9	216.9
Total Expenses ...	464.5	476.4	953.0	1100.1	1343.6	1392.6	1033.3	1034.6
Total Expenses per 100 Acres ...	175.4	179.9	453.7	523.8	1331.6	1294.1	864.6	865.7

CHANGES IN ORGANISATION AND INCOMES ON SOME FARMS IN WALES (1932-33—1936-37)

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During the period 1920 to 1933 agriculture was passing with minor interruptions through a prolonged period of depression accompanied generally by a downward trend in prices. The year 1932-33, however, appears to mark the end of the decline in prices which characterised the earlier years and from this period onwards there has been an improvement in the general price level and in farming conditions generally. The improvement in agricultural prices was not shared by all branches of the industry and in the case of some farm products prices fell after 1932-33 and recovery was not made until 1935-36 and even up to 1936-37 but in the latter year they stood above the 1932-33 price level. Improvement in the farmers' financial position would therefore be influenced by the type of farming pursued and the improvement or decline in the price of the commodities sold.

Since the price level has tended to rise since 1933 it may be of interest to examine the records of 39 farms which have continuously kept accounts during the period 1932-33 to 1936-37 to see how these have fared and to ascertain whether any changes have taken place in the economic organisation of the group. The relative importance of the various farm products sold on these farms may be gauged from the following figures which give the percentage composition of the farm receipts on a five years basis. These proportions do not show any considerable variation from year to year.

Percentage Composition of Receipts.
(5 Years Average).

Commodity.	*Per cent.*	*Commodity.*	*Per cent.*
Cattle	20.8	Poultry and Eggs ...	8.7
Milk	27.5	Horses	2.4
Other Dairy Products	2.3	Crops	5.6
Sheep and Wool ...	13.8	Sundries	2.6
Pigs	16.8		
		Total	100.0

These figures clearly indicate that the receipts on these farms will be greatly influenced by the price of cattle and milk and to a lesser extent by the price of pigs, sheep, poultry and eggs. Crops are not an important item. Price movements for these commodities for the whole of England and Wales are given in Table I, and while these may not represent actual conditions in the group of farms discussed they do at any rate indicate the general trend of prices during the period 1932-33 to 1936-37.

Size, Rentals and Types of Farming.

In size this group of farms averaged 128 acres and ranged from 18 to 365 acres. Average rent is about 17s. 7d. per acre with variation between one farm and another of from 2s. 9d. to 56s. 4d. per acre. Rents and sizes of the individual farms show no great changes over the whole period. As regards quality of soil, size of farm and type of farming this group is varied in character. From a knowledge of the farms together with examination of receipts eight of the farms could be classified as

TABLE I.

Index Numbers of Prices for Crop Years.*

Base 1911-13 - 100.

Commodity.	*Crop Years (September to August).* 1932-33	1933-34	1934-35	1935-36	1936-37
Fat Cattle	103	100	92	95	103
Fat Cattle (including Subsidy) ...	—	—	107	113	118
Store Cattle	101	86	87	94	106
Dairy Cows	109	105	102	103	111
Milk	147	161	171	177	176
Bacon Pigs	96	112	106	106	119
Porkers	102	120	112	108	120
Store Pigs	109	142	132	126	139
Fat Sheep	108	120	128	115	141
Store Sheep	80	95	108	112	127
Wool	66	80	87	94	127
Poultry	127	121	119	119	121
Eggs	107	103	105	115	121
General Index	106	113	115	117	130
General Index (incl. Subsidies) ...	110	117	121	128	134
Feedingstuffs	88	84	92	87	114
Fertilisers	89	90	89	89	90

* Extracted from the Ministry of Agriculture and Fisheries Market Reports,

Cattle and Sheep farms on poor land, seven as Cattle and Sheep farms on better land, eight as Mixed farms and sixteen as Cattle and Milk farms. While it is fully recognised that 39 farms do not comprise an adequate statistical sample and that the data cannot be regarded as representative in the absolute sense of any particular type or size of farm the fact that the records over the five years are for the same holdings gives some significance to the results obtained.

Land Utilisation.

The total area covered by these farms in each year together with the average size and percentage of arable land is herewith stated.

Year.	*Total Acres.*	*Acres (Per Farm).*	*% Arable to total.*
1932-33	4,721	121	11.4
1933-34	4,714	121	10.1
1934-35	4,827	124	11.2
1935-36	4,849	124	11.3
1936-37	4,849	124	10.7
Average (5 years)	4,792	123	10.9

In average use of land about 11 per cent. was used for arable crops, 20 per cent. for hay, 42 per cent. for permanent pasture and 27 per cent. for rough grazing and these proportions have not shown any great variation from year to year. Compared with average conditions as indicated by the Agricultural Statistics for Wales for the same period this group of farms appear to embrace land of better quality in that the group as a whole show less area under rough grazing and a higher proportion of land under arable crops, hay and permanent pasture. In the main, crops are grown for the maintenance of livestock and crop sales over the five year period averaged less than 6 per cent. of total receipts. While these farms have maintained about the same area of land in each year and about the same proportion of arable to grassland some changes have taken place in the nature of the cropping. It might have been expected that under the stimulus of the Wheat Act the farms would have shown a definite increase under wheat, but apart from 1934-35, when the wheat area increased by 27 per cent. as compared with the previous year, the acreage under wheat has kept comparatively steady during the whole period. The area under barley fluctuated from year to year but after 1934-35 showed a definite tendency to decline. There was a steady reduction in the area

under oats from 1932-33 to 1934-35, but against this there was an increase in the area under mixed corn during the same period. In 1935-36 there was an increase in both crops (oats and mixed corn) and taking the two crops together the acreage was nearly 8 per cent. above that recorded in 1932-33. The increased area of oats in 1936-37 was largely obtained at the expense of the mixed corn area. Taking all corn crops there was a decline in area in 1933-34, this was followed by an increase in 1934-35, then a decline in 1935-36 and again in 1936-37 and the total area under corn on these farms in that year was nearly 3 per cent. less than in 1932-33. There was a continuous decline in the area under potatoes amounting to about 21 per cent. between 1932-33 and 1936-37. The trend in the case of turnips and swedes was similar with a reduction in acreage of 45 per cent. during the same period. This contraction in the turnips and swedes area was largely compensated by the increased acreage under mangolds and rape and kale. Between 1932-33 and 1936-37 the area under mangolds increased by nearly 70 per cent. and rape and kale together by nearly 87 per cent. The use of mangolds and kale for the feeding of a larger head of dairy cows and the substitution of rape in place of turnips and swedes for the feeding of sheep was mainly responsible for this change.

While these farms show a higher proportion of the land under arable crops than that recorded for Wales, it is noticeable that the same general tendency to increase or decrease the arable area and also some of the crops is common to both records. The percentage of arable land under the different crops on these farms gives a better indication of their relative importance. These are given in Table VIII.

Summarising the changes in the cropping system, the records indicate slight fluctuations in the corn area from year to year with a tendency to decline after 1934-35. Other facts which emerge from the records is the decline in the potato and turnip and swedes area with an increase in the mangolds, rape and kale area.

Available supplies of home grown foods as feed for livestock and for sale will be influenced by the yield of the crops grown. Information on yields is not sufficiently complete for these farms to warrant any statement of the effect of yields on available supplies. According to the Ministry of Agriculture's ***Statistics*** the variation in the yield of crops for Wales during the period

covered by these farms was as follows :—The average annual yield of wheat varied from under 15 cwt. per acre (1936) to slightly over 16¼ cwt. (1934), barley from nearly 18¼ cwt. (1934) to 14 cwt. (1932 and 1935) and oats from nearly 13¼ cwt. (1936) to 14 cwt. per acre in 1935. Potatoes varied from slightly over 5 tons per acre (1935) to 6 tons (1933), turnips and swedes from nearly 9 tons (1934) to nearly 13½ tons (1932) and mangolds from 16 tons (1933) to 16¾ tons per acre in 1935. The variation in yield of hay (clover) was from 22 cwt. per acre (1933 and 1934) to nearly 22¾ cwt. (1937) and hay (meadow) from nearly 17½ cwt. (1934) to nearly 19 cwt. per acre in 1936.

Livestock Carried.

The livestock figures are based on a monthly census of the livestock carried on these farms and therefore provide a fairly reliable record of the number kept and any changes in the number and classes of livestock from year to year. Work horses show a tendency to decline but throughout the whole period average slightly over two work horses per 100 acres. " Other " horses showed a slight reduction between 1932-33 and 1934-35 but increased in 1935-36 and again in 1936-37. The mean number of dairy cows increased by 17 per cent. between 1932-33 and 1936-37 but the records do not indicate any great change in the number of " other " cattle. Slight fluctuation in the number of breeding ewes is noticeable but on the whole they have remained fairly steady and the same applies to " other " sheep. The pig population increased very rapidly between 1933-34 and 1935-36 but declined to some extent in 1936-37. The number of sows on these farms in 1935-36 was 47 per cent. greater than in 1932-33 and the total pig population had nearly doubled during that period. The number of breeding sows in 1936-37 as compared with the previous year had declined by about 6 per cent. and total pigs by 4 per cent. The outstanding increase in the pig population appears to be due to the establishment of the Pigs Marketing Board as with quantitative control of imports and fixed prices farmers could hope for better and more stable returns. The decline in the number of pigs after 1935-36 may be traced to the breakdown of the contract scheme together with the rise in the price of feedingstuffs. Poultry flocks increased between 1932-33 and 1934-35 by nearly 25 per cent. but declined in the next two years. In 1936-37 they were 14 per cent. below that recorded in 1934-35. Compared with average conditions

for Wales these farms are superior in stock carrying capacity as regards horses, cattle, pigs and poultry and while the number of breeding ewes is very similar the total sheep population per 100 acres is below that recorded for the whole of the Principality. (See Table IX.)

Farm Capital.

The capital represented is approximately the current money value of tenants' fixtures, crops growing and harvested, livestock and dead stock (implements, etc.) and the figures are the means of the opening and closing valuations. The principles adopted for valuations are :—Standard values are applied in the case of all productive classes of livestock so that increases or decreases are thus mainly due to changes in numbers. Livestock expected to be ready for sale in the year following day of valuation are valued as nearly as possible at market values. In the case of crops these are also valued at standard rates as they are not an important item of sales. Machinery, implements, tenants' fixtures are depreciated at standard rates, current repairs, etc., are charged in expenses. Additions are included in expenses but are then carried to capital account. This will tend to minimise the actual decline or increase in the farm capital as any price fluctuations will only be reflected in the capital invested in stock intended for early sale. The capital as here defined is given in Table X. Between the years 1932-33 and 1936-37 there was an increase in farming capital of about 6 per cent. and during the same period the increase in the capital in livestock was nearly 11 per cent. The most striking change was in the capital invested in pigs and poultry. Owing to a marked rise in numbers and values, the capital in pigs nearly doubled between 1932-33 and 1936-37. With poultry there was an increase of 30 per cent. in capital between 1932-33 and 1934-35 but with the decline in poultry flocks the capital in 1936-37 was only about 9 per cent. above that in 1932-33.

Over the whole period the average capital invested was about £8.1 per acre with variations of between £7.9 and £8.5 per acre. On an average about 67 per cent. of the capital is invested in livestock, 12 per cent. in crops and about 21 per cent. in implements and these proportions remain fairly constant from year to year.

Financial Results.

Briefly the simple results as regards the expenditure,

receipts and differences in valuation are shown by these figures :—

Per Farm.

Year.		*Receipts.* £	*Expenses.* £	*Surplus.* £	*Valuation Difference.* £	*Farm Income.* £
1932-33	...	652	579	73	— 38	35
1933-34	...	709	651	58	+ 32	90
1934-35	...	831	715	116	+ 15	131
1935-36	...	866	756	110	+ 60	170
1936-37	...	891	770	121	+ 33	154
Average (5 Years)		790	694	96	+ 21	117

Per 100 Acres.

Year.		*Receipts.* £	*Expenses.* £	*Surplus.* £	*Valuation Difference.* £	*Farm Income.* £
1932-33	...	539	479	60	— 30	30
1933-34	...	587	539	48	+ 26	74
1934-35	...	672	578	94	+ 12	106
1935-36	...	696	608	88	+ 49	137
1936-37	...	716	619	97	+ 27	124
Average (5 Years)		643	565	78	+ 17	95

Receipts include value of the farm produce consumed in the house and rent of farm house at rateable value. Expenses include wages due or paid to family labour other than that of the farmer and his wife. In all years there was a surplus of receipts over expenses but on the basis of cash balance the worst year for this group was 1933-34 but in that year there had been a considerable increase in certain items of expenditure. Cost of implements had more than doubled, and expenses incurred in the purchase of horses and pigs increased by over 100 per cent. There was, however, a distinct improvement in the cash balance in 1934-35 and although there was a slight decline in 1935-36 the position was more than recovered in 1936-37. Between 1932-33 and 1936-37 the surplus of receipts over expenses had increased by nearly 62 per cent. Valuation differences only show a depreciation of capital in 1932-33. Other years show varying amounts of appreciation in capital—depending partly on movements in prices and partly on stocks in hand. The financial results for these farms may now be considered in terms of gross income, farm income and labour income. The statements of income need full understanding of the methods of calculation.

Family income includes all the earnings of the farm family, " profits " as usually understood, wages of sons and daughters earned on the farm, value of produce consumed and enjoyment of house.

Farm income excludes wages of sons and daughters, but includes value of produce consumed and enjoyment of house. It represents the profits to the occupier (the farmer and his wife)

and is in fact the difference between receipts and expenditure plus or minus valuation differences.

Labour Income. But as the " farm income " includes what is in effect payment to the farmer and often in part to his wife for manual labour done the further calculation of " labour income " is made. This is " farm income " minus allowance for interest on capital at the rate of 6 per cent. per annum. This " labour income " is then the earnings of the farmer and his wife in manual labour and management on the farm.

Per Farm.

Year.		*Gross Income.*	*Farm Income.*	*Labour Income.*
		£	£	£
1932-33	...	76	35	21
1933-34	...	129	90	32
1934-35	...	168	131	72
1935-36	...	211	170	109
1936-37	...	199	154	91
Average (5 years)	...	156	117	56

Per 100 Acres.

Year.		*Gross Income.*	*Farm Income.*	*Labour Income.*
1932-33	...	63	30	18
1933-34	...	106	74	27
1934-35	...	136	106	58
1935-36	...	170	137	88
1936-37	...	160	124	73
Average (5 years)	...	127	95	46

In 1932-33 the average farmer's earnings were about 13s. per week, and about 35s. in 1933-34. In the following two years earnings averaged 50s. and 65s. per week respectively. Farmers' earnings declined in 1936-37 and only average 59s. per week and over the whole period (1932-37) earnings averaged 45s. per week. Allowing interest on capital at 6 per cent., the managerial earnings of the farmer in 1932-33 amounted to about 8s. and 12s. per week in 1933-34. There was some improvement in the next two years when the farmer earned on an average as manager 28s. in 1934-35 and 42s. per week in 1935-36. Managerial earnings in 1936-37 averaged 35s. and for all years (1932-37) about 22s. per week.

Changes in Receipts and Expenditure.

As previously stated there were hardly any changes in area for the group and acreage under arable crops, hay, pasture and rough grazing were very similar in all years. There were some changes in the nature of the crops grown. Number of classes of horses and sheep were fairly steady. There was a definite increase in the number of pigs and poultry and some increase in the

number of dairy cows. Changes therefore likely to affect sales were in pigs, poultry and dairy cows.

The items making up the yearly receipts are stated as a percentage of the items in 1932-33 are shown in Table II.

TABLE II.

Increase or Decrease in Receipts.
Base 1932-33 = 100.

Year.	*1933-34*	*1934-35*	*1935-36*	*1936-37*
Cattle	90	104	114	130
Butter	92	71	69	66
Milk	103	113	125	120
Cheese	67	64	27	28
Cream	108	51	37	38
Total Dairy Products .	102	108	119	113
Sheep and Wool ...	111	131	132	147
Pigs	131	186	182	198
Poultry and Eggs ..	109	119	121	112
Horses	177	155	156	145
Total Livestock and Livestock Products ...	107	124	129	134
Crops	117	124	111	103
Sundries	205	183	205	163
Total Receipts ...	109	125	130	133

The percentage composition of the different items in the farm receipts are shown in Table XI. The proportion which the different farm products bear to total sales vary only to a slight degree for some commodities and in others to a greater degree from year to year. The degree of variation is influenced partly by price changes and partly by the quantity of the product produced. While these variations do occur, the figures indicate very clearly that sales of milk is the largest single item of receipts in each year for the group and represents between 26 to 29 per cent. of the sales over the whole period. Farm receipts increased in each year from £5 7s. 9d. per acre in 1932-33 to £7 3s. 3d. per acre in 1936-37.

While total sales for these farms have increased the output has been obtained at a higher cost and total expenditure has increased each year from an average of £4 15s. 8d. per acre in 1932-33 to £6 3s. 7d. per acre in 1936-37. With regard to labour (Table III) the number of persons employed has kept about the same throughout the whole period. Excluding the work of the

occupier and his wife there is a slight increase noticeable in the number employed during the period 1935-37.

In the case of horse labour, owing to the introduction of tractors and motor vehicles on some of the farms, the number of work horses has declined by 5 per cent. between 1932-33 and 1936-37.

Expenditure on labour represents wages paid or due to sons, daughters and relatives working on the farm and for hired labour. There were no striking changes in the labour bill except that a slight decline is noticeable after 1933-34. Apart from a definite increase in the price of feedingstuffs in 1936-37 (when the general index rose to 114 as compared with 87 for the previous year) there was no appreciable difference in unit costs during the period reviewed. The increase in the requirement of stock in the nature of additional pigs and poultry foods, together with the tendency to fatten more cattle and sheep and the feeding of cows for increased milk production would be responsible for the higher expense incurred on bought foods. Unit costs of fertilisers have remained practically the same during the five years and a quantitative increase is the primary cause of the higher expenditure on manures. The reduction in expenditure in 1936-37 appears to be due to an attempt to curtail outlay on manures in order to meet the rise in the price of feedingstuffs. Expenditure on total livestock purchased increased by 59 per cent. between 1932-33 and 1936-37 and changes in expenditure are partly due to improvement in livestock prices but mainly to the number of livestock bought.

TABLE III.

Number of persons employed per 100 Acres.

	1932-33	*1933-34*	*1934-35*	*1935-36*	*1936-37*	*All years.*
	No.	*No.*	*No.*	*No.*	*No.*	*No.*
Farmer and Wife ...	0.77	0.77	0.81	0.76	0.71	0.76
Other Family Labour	0.44	0.46	0.39	0.45	0.50	0.45
Total Family ..	1.21	1.23	1.20	1.21	1.21	1.21
Hired Labour ...	1.09	1.07	1.11	1.14	1.11	1.10
Total Persons including Farmer and Wife ...	2.30	2.30	2.31	2.35	2.32	2.31
Total Persons excluding Farmer and Wife ...	1.53	1.53	1.50	1.59	1.61	1.55
Work Horses ...	2.21	2.20	2.16	2.13	2.11	2.16

TABLE IV.

Increase or Decrease in Expenses.
Base 1932-33 = 100.

Year.	1933-34	1934-35	1935-36	1936-37
Rent	100	99	97	97
Rates	91	83	102	101
Wages (Hired) ...	107	105	102	103
Wages (Family) ...	100	92	102	110
Total Wages	106	102	102	105
Feedingstuffs	110	111	134	155
Manures	104	106	144	121
Seeds	95	102	119	104
Implements	206	100	132	134
Sundries	120	155	182	149
Horses Bought ...	211	161	205	121
Cattle Bought ...	88	88	140	125
Sheep Bought ..	97	198	184	232
Pigs Bought ...	218	241	197	218
Poultry and Eggs for Hatching	128	137	156	123
Total Livestock Bought	123	189	162	159
Total Expenses ...	113	121	127	129

Cost of labour, feedingstuffs and purchases of livestock constitute the major part of the farm expenses and represented from one year to another between 66 and 71 per cent. of the total expenses. Expenditure on labour varied between 20 and 25, feedingstuffs between 23 to 28 and purchases of livestock from 18 to 24 of the total charges. (See Table XII.)

Farm Output [1]

From 1932-33 to 1935-36 there was a definite increase in the farm output and production stood at 41 per cent. above that in 1932-33 (Table V). In the following year there was a decline in output of 8 per cent. Cattle remained up to 1934-35 below 1932-33 output but in the following two years were 26 per cent. above the 1932-33 output. The output in sheep more than doubled in 1933-34 and was three times as much in the following

[1] The *farm output* is calculated, in the case of livestock by taking the total value of the stock on hand at the beginning of the year plus purchases and deducting from it the value of stock on hand at the end of the year and adding the value of the sales. The same method has been used in the case of crops. No deductions have been made for the cost of foods fed to livestock and in the case of crops the cost of seeds and artificial manures have been omitted.

three years. Dairy produce output increased gradually up to 19 per cent. in 1935-36, then declined by 6 per cent. in 1936-37. The output in pigs increased considerably between 1932-33 and 1936-37 and in the latter period had more than doubled. Output in poultry increased up to 19 per cent. in 1934-35 then declined and in 1936-37 was 7 per cent. above the 1932-33 output. The outputs in horses and crops are variable and show no definite tendencies.

The values of the farm output per 100 acres and per person have risen at about the same rate (Table VI). This increase in values arises partly as a result of internal and partly through external influences. The records for these farms clearly indicate changes in the type of stock kept and to some extent in the nature of the crops grown. These changes together with the improvement in prices after 1932-33 would be responsible for the increase in the value of the output. The value of the farm output per person averaged £182 in 1932-33 and £249 in 1936-37, or an increase of 37 per cent. As wages are one of the major items of expense on these farms the efficient organisation of labour with a high output per worker employed appears to be one of the essentials to ensure profits.

TABLE V.

Increase or Decrease in Farm Output.
Base 1932-33 = 100.

Year.	*1933-34*	*1934-35*	*1935-36*	*1936-37*
Cattle	81	93	126	126
Butter	62	54	42	36
Milk	109	118	133	127
Cheese	61	55	17	31
Cream	130	63	45	46
Total Dairy Produce ...	103	108	119	113
Sheep and Wool ..	245	305	305	324
Pigs	163	201	187	215
Poultry and Eggs ...	114	119	99	107
Horses	693	1,277	1,127	861
Total Livestock and Livestock Products ...	118	134	141	144
Crops	66	119	183	84
Sundries	145	117	146	94
Total Farm Output ...	114	182	141	138

TABLE VI.

Farm Output.

(Per 100 Acres and per manual worker).

Year.		*Value of Farm Output.*			
		Per 100 Acres.	*Index.*	*Per Person.**	*Index.*
		£		£	
1932-33	...	419	100	182	100
1933-34	...	479	114	208	114
1934-35	...	554	132	240	132
1935-36	...	589	141	251	138
1936-37	...	577	138	249	137

* Including manual work of occupier and wife.

Social Output.

The amount and distribution of the social output is shown in Table VII.

TABLE VII.

Amount and Distribution of Social Output.

Per 100 Acres.

			1932-33	1933-34	1934-35	1935-36	1936-37	*Average. All years*
			£	£	£	£	£	£
Wages (1)	...	...	120	127	122	123	125	123
Rent (2)	...	...	89	89	86	86	87	88
Profits (3)	...	...	30	74	106	137	124	95
Total	...	...	239	290	316	346	336	306
					Per cent.			
Wages (1)	...	...	50.3	43.9	38.6	35.6	37.2	40.3
Rent (2)	...	...	37.3	30.6	27.8	24.8	25.9	28.7
Profits (3)	...	...	12.4	25.5	33.6	39.6	36.9	31.0
Total	...	...	100.0	100.0	100.0	100.0	100.0	100.0

(1) Includes wages of family other than occupier and wife.

(2) When a farm is owner-occupied, a rental value has been charged.

(3) This represents the sum available to the occupier (the farmer and his wife) for their labour and capital investment. It includes an allowance for farm produce consumed and rent of farm house.

As previously stated very little variation occurred in the expenditure on labour from year to year and the wages bill has been maintained at a comparatively stable level. Rents on the whole show a downward trend. Profits increased considerably between 1932-33 and 1935-36 and then declined to some extent in the following year. While the better profits may be attributed to some extent to the improvement in prices of agricultural produce since 1933, it does appear that they are mainly due to

internal changes in the organisation of the farm, in the quantity and type of output and to better and more efficient methods of production. Between 1932-33 and 1936-37 the total social output per acre increased by 45 per cent. but declined in the following year by 5 per cent.

TABLE VIII.

Land Utilisation.

Crop.	*Per 100 Acres.* 1932-33	1933-34	1934-35	1935-36	1936-37	Aver. all yrs	*Per 100 acres (Wales*)* 1933.	1934.	1936.
	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres
Corn ...	8.0	7.5	8.4	8.0	7.6	7.9	5.3	5.5	5.1
Other Crops ...	3.4	2.7	2.8	3.4	3.1	3.1	2.2	2.1	2.1
Total Arable	11.4	10.2	11.2	11.4	10.7	11.0	7.5	7.6	7.2
Hay ...	20.0	19.9	19.8	20.4	21.0	20.2	17.7	17.9	17.4
Pasture ...	42.5	43.1	41.7	41.1	41.5	42.0	36.2	35.7	36.3
Rough grazing	26.1	26.8	27.3	27.1	26.8	26.8	38.6	38.8	39.1
Total Pasture	88.6	89.8	88.8	88.6	89.3	89.0	92.5	92.4	92.8
Total Acres ...	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	Percentage Composition of Arable Land.								
Wheat ...	13.3	15.6	17.7	14.1	13.9	14.9	6.4	7.2	6.3
Barley ...	11.8	9.6	12.5	8.3	6.9	9.8	9.1	8.4	8.6
Oats ...	39.6	41.2	35.7	37.1	42.6	39.2	49.4	49.7	50.0
Mixed Corn ...	5.9	6.9	9.1	10.7	7.6	8.1	6.2	6.3	6.2
Total Corn	70.6	73.3	75.0	70.2	71.0	72.0	71.1	71.6	71.1
Potatoes ...	6.5	6.1	5.4	5.1	5.4	5.7	6.4	5.9	5.5
Turnips and Swedes ...	6.9	6.3	5.3	5.2	3.9	5.5	11.6	10.3	9.9
Mangolds ...	2.7	3.1	4.1	4.0	4.7	3.8	2.8	3.1	3.3
Rape and Kale	4.2	2.7	3.5	8.3	8.2	5.4	3.4	4.0	5.3
Other Crops ...	9.1	8.5	6.7	7.2	6.8	7.6	4.7	5.1	4.9
Total ...	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

* Extracted from the Ministry of Agriculture Statistics Part I. 1933, 1934 and 1936.

TABLE IX.

Average Number of Livestock Carried.

	Per 100 Acres.						*Per 100 Acres (Wales)* *	
	1932-33	1933-34	1934-35	1935-36	1936-37	Aver. All yrs	1934	1936
	No.	*No.*	*No.*	*No.*	*No*	*No.*	*No.*	*No.*
Work Horses	2.2	2.2	2.2	2.1	2.1	2.2	1.6	1.6
Other Horses	0.9	0.7	0.7	0.9	1.0	0.8	1.0	1.1
Total Horses	3.1	2.9	2.9	3.0	3.1	3.0	2.6	2.7
Dairy Cows	8.1	9.2	9.0	9.2	9.5	9.0	7.9	8.2
Other Cattle	14.9	15.6	15.1	14.5	15.1	15.1	11.2	10.7
Total Cattle	23.0	24.8	24.1	23.7	24.6	24.1	19.1	18.9
Breeding Ewes	46.0	50.0	46.0	45.0	47.0	47.0	44.0	46.0
Other Sheep	31.0	31.0	32.0	31.0	31.0	31.0	49.0	51.0
Total Sheep	77.0	81.0	78.0	76.0	78.0	78.0	93.0	97.0
Breeding Sows	1.1	1.1	1.5	1.7	1.6	1.4	0.8	0.8
Other Pigs	6.8	10.2	13.0	13.5	13.0	11.3	4.6	4.9
Total Pigs	7.9	11.3	14.5	15.2	14.6	12.7	5.4	5.7
Laying Flock	76.0	81.0	92.0	88.0	75.0	82.0	—	—
Other Poultry	52.0	59.0	65.0	51.0	59.0	58.0	—	—
Total Poultry	128.0	140.0	157.0	142.0	131.0	140.0	100.0	100.0
Total Animal units (Cow)	31.0	37.0	37.0	32.0	33.0	34.0	—	—

Extracted from the Ministry of Agriculture Statistics Part I, 1934 and 1936.

TABLE X.

Percentage Composition of Capital Invested.

Year.	1932-33	1933-34	1934-35	1935-36	1936-37	*All Years.*
Item.	%	%	%	%	%	%
Horses	7.5	7.4	7.6	8.1	8.5	7.9
Cattle	38.6	39.5	38.3	38.7	39.6	38.9
Sheep	11.6	12.4	12.2	12.5	13.0	12.9
Pigs	2.6	3.7	5.4	5.1	4.6	4.8
Poultry	2.9	3.3	3.7	3.8	3.0	3.3
Total Livestock ..	66.2	66.3	67.2	67.7	68.7	67.3
Crops and Cultivations ...	13.6	12.5	11.3	11.6	11.2	12.0
Implements	19.6	20.7	21.0	20.5	19.7	20.2
Other Items	0.6	0.5	0.5	0.4	0.4	0.5
Total	100.0	100.0	100.0	100.0	100.0	100.0
	£	£	£	£	£	£
Total Capital (per Farm) ...	968.9	962.7	985.8	1023.3	1050.9	988.3
Total Capital (per 100 Acres)	800.3	796.7	796.6	822.9	845.2	812.6
Relative Total Capital ...	100.0	99.5	99.5	102.8	105.6	—

TABLE XI.

Percentage Composition of Receipts.

	1932-33	1936-37	*All years Average.*
	%	%	%
Cattle	22.4	21.9	20.8
Butter	2.8	1.4	1.9
Milk	29.8	26.4	27.5
Cheese and Cream	0.7	0.2	0.4
Total Dairy Produce ...	32.8	28.0	29.8
Sheep and Wool	13.2	14.6	18.9
Pigs	12.6	18.7	16.8
Poultry and Eggs	9.2	7.8	8.6
Horses	2.0	2.1	2.4
Total Livestock and Livestock Products	92.2	93.1	91.3
Crops	6.0	4.7	5.6
Sundries	1.8	2.2	2.6
Total Receipts	100.0	100.0	100.0
	£	£	£
Total Receipts (per Farm) ...	652.2	890.9	789.9
Total Receipts (per 100 Acres)	588.7	716.5	642.9
	Produce consumed in Farm house. (Already included in Receipts).		
	£	£	£
Per Farm	36.4	30.0	33.5
Per 100 Acres	30.0	26.5	27.8

TABLE XII.
Percentage Composition of Expenses.

	1932-33	1936-37	*All Years Average.*
	%	%	%
Rent	18.6	14.0	15.5
Rates	1.2	1.0	1.0
Wages (Family)	18.4	14.6	16.1
Wages (Hired)	6.7	5.7	5.7
Total Wages	25.1	20.3	21.8
Feedingstuffs	23.6	28.2	25.5
Manures	1.9	1.8	1.9
Seeds	1.3	1.0	1.2
Implements	3.2	3.3	3.6
Sundries	6.5	7.5	7.9
Total Direct Expenses ...	81.4	77.1	78.4
Horses	1.2	1.2	1.7
Cattle	10.6	10.3	9.7
Sheep	2.9	5.1	3.9
Pigs	3.4	5.9	5.8
Poultry	0.5	0.4	0.5
Total Livestock	18.6	22.9	21.6
Total Expenses	100.0	100.0	100.0
	£	£	£
Total Expenses (per Farm) ...	579.4	769.5	694.1
Total Expenses (per 100 Acres)	478.6	618.8	565.0

INSOLVENCY IN FARMING.

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There are many ways of measuring the depth of a depression or the height of prosperity in agriculture. Most of the methods adopted however merely indicate changes in certain aspects of the problem. By the use of the Index Number of agricultural prices attempts are made to measure changes in the value of commodities sold, but the position of the Index does not necessarily indicate a state of prosperity or adversity in the industry. Costs of production may move almost in harmony with changes in prices and in consequence the farmers' financial position may remain unaltered in spite of movements in the value

of commodities sold. At times, in fact, the prices of farmers' raw materials advance more rapidly than those of saleable products and as a result the producers' position may be deteriorating although the Agricultural Index shows an upward trend.

In farming as in all other occupations a certain number of individuals are unable to show financial success whatever the general economic conditions of the industry. In periods of depression the number of failures in most industries shows a definite rise whereas in prosperous times it is generally very low, but even under the most favourable circumstances certain business people are unable to meet their liabilities and become insolvent. A considerable amount of capital is undoubtedly lost in farming through failures in which creditors do not suffer but as the results do not become public knowledge there is no record of losses suffered in this way by those who invest capital in their own farming businesses. Yet a number of farmers[1] and others who carry on agricultural businesses find their way to the bankruptcy court or meet their state of insolvency in ways which result in publication of the details of their business affairs.

The organisation of agriculture along with perhaps the building and the main lines of the distributive trades has remained almost unchanged over a long period of time. In agriculture particularly, private businesses predominate and partnerships are not uncommon. They are generally small and frequently family concerns, and the capital investment in each case is often comparatively low. In many urban industries on the other hand joint stock companies have become increasingly important. In case of failure these do not become bankrupt but their affairs are wound up in other ways. In view of the fact that this form of organisation is very uncommon in agriculture a study of insolvencies gives a fairly accurate view of the extent of financial failures.

The affairs of insolvent farmers may be settled in one of several ways. In some cases assistance may be obtained from relatives or friends and all liabilities may be met in full. In general, however, they are settled according to the requirements of the Bankruptcy Acts, or the Deeds of Arrangement Act. Under the Bankruptcy Acts a Court generally makes a receiving order against the debtor on his own petition or on that of one or more creditors. Deeds of Arrangement on the other hand are

[1] Including graziers.

made between the debtor and creditor without the intervention of a Court and, as a result, the assets are handed over to the creditors. All such cases are now recorded by the Board of Trade.

Price Movements and Insolvency.

The causes of business failures can be roughly divided into two classes, those primarily personal and those of an economic nature. Those falling into the former class defy analysis but it is possible to examine the relationship between the extent of insolvency in an industry and its economic conditions. During the last decade there has been a close association between the number of insolvencies amongst farmers and the general price level of farm products.

TABLE I.

Insolvencies amongst Farmers in England and Wales.

Year.	*Number of Failures.*	*Index**	*Index of Prices of Agricultural Produce.*	*Liabilities.*
				£
1927	478	148	144	1,137,166
1928	462	143	147	898,442
1929	345	107	144	678,949
1930	350	108	134	779,586
1931	497	154	120	1,068,847
1932	600	186	112	1,297,263
1933	428	133	107	797,842
1934	288	89	114	478,557
1935	224	69	117	330,179
1936	215	66	122	339,336

* Average 1911-13 = 100.

During the immediately pre-war years—a period of comparative stability—the number did not show violent fluctuations. The war period and the years immediately following were of course abnormal and until 1920 the number of failures was extremely low.[2] With the set-back in prices, which commenced in 1921, there was a rise again and until 1931 the average number of failures per annum was 408 as compared with 302 during the period 1906-13. With the advent of the economic depression in 1931 the number rose again to attain the maximum figure of 600 in 1932. It is true that most industries suffered from the effects of the depression and measured in some ways

[2] See Appendix.

it appears that agriculture suffered to a lesser degree, at least prices in general fell to a greater extent than those of agricultural commodities. In the pre-war years the annual average liabilities varied around one-third of a million sterling, but in several of the post-war years it exceeded one million pounds. The total liabilities since 1920 have in some years been much heavier than would be accounted for by the fall in the value of money compared with the pre-war period as the following table shows.

TABLE II.
Average Liabilities per Case.
(Farmers and Graziers).

Year.	*Actual.*	*Adjusted by:* Index of General Prices.	*Adjusted by:* Index of Agricultural Prices.
	£	£	£
1927	2,379	1,736	1,652
1928	1,944	1,440	1,322
1929	1,967	1,548	1,366
1930	2,227	2,101	1,662
1931	2,150	2,415	1,791
1932	2,162	2,514	1,930
1933	1,864	2,167	1,742
1934	1,661	1,845	1,457
1935	1,474	1,568	1,260
1936	1,578	1,578	1,293

Average Liability 1909-13 – £1,069.

Comparing the average pre-war liabilities of £1,069 with these figures, it appears either that the businesses in which failure has occurred since 1927 were larger than those which failed in the pre-war days, or that the average rate of capitalisation of agriculture is higher than previously. If the pre-war period may be regarded as normal, then it is known that small farms tend to stand the strains of depressions better than large farms, and failures would be expected to be a little more frequent on the larger than on the smaller farms. The average rate of capitalisation, in money values, has fluctuated with prices; but in actual quantities of live and dead stock combined it has tended to rise.

Time Lag: Price changes and Insolvency.

In so far as changes in prices are responsible for failures a certain time lag would normally be expected. A serious fall in revenue due to a decline in the value of goods sold may drive farmers to draw on capital for a time and the length of the

period during which they were able to hold out against unfavourable circumstances would of course depend upon the extent of their reserves and the leniency of their creditors. It seems however that the time lag is comparatively short, in general about a year. Of course farmers may suffer from price movements both as buyers and sellers. A rise in costs of raw materials may be as serious as a fall in the value of saleable goods. In recent years there has been a movement towards specialisation in farming, and in general, greater reliance is placed on purchased raw materials, such as feeding stuffs, than was formerly the case. The factor to show the most important change, however, has been the wages of labour and this has certainly called for greater efficiency in the use of man power. On the whole, however, it seems that unfavourable conditions exert their effects upon the number of insolvencies very quickly and there is no indication of any appreciable time lag.

Failures in All Industries.

It is difficult to make any accurate comparison between farming and other businesses in the matter of insolvencies. A considerable proportion of the business of production and trade outside agriculture is carried on under the joint-stock system of capital organisation, and losses suffered owing to the failure of such companies are not recorded in the bankruptcy returns. With this essential qualification however, the failures in farming can be compared with the total recorded for all businesses in the country. One interesting point elucidated in Table 8 is the

TABLE III.

Total Failures.

	All Businesses.		*Proportion in Farming to the whole.*	
Year.	*No.*	*Liabilities.*	*% of No.*	*% of Liabilities*
		(£100).		
1927	6,170	12,754	7.7	8.9
1928	6,221	12,258	7.4	7.8
1929	5,900	14,386	5.8	4.7
1930	6,287	15,093	5.5	5.1
1931	6,818	16,527	7.8	6.4
1932	7,321	16,422	8.2	7.9
1933	6,212	10,413	6.9	7.6
1934	5,484	9,822	5.7	4.8
1935	5,158	10,976	4.8	8.0
1936	4,847	7,493	6.2	2.2

change in the proportion of failures in farming in relation to those suffered by all industries.

Between 1927 and 1933 the total number of insolvencies in all industries was appreciably above the average of the pre-war years. Subsequently however there was a significant and rapid fall and during the last three years of the period the number has been abnormally low. This improvement in the position was undoubtedly due in a large measure to the recovery of many branches of industry. After a severe economic depression, a heavy fall in the number of failures during subsequent years would normally be expected. At all times there must be marginal producers operating in an industry, persons who, owing to lack of business ability or to the paucity of the natural resources with which they work, are very sensitive to changes in general economic conditions. Owing to one or other of these factors or to a combination of both such producers are in normal times only just able to continue in business, as, on the average, receipts exceed expenses by a comparatively small margin and on this they continue to survive. In periods of prosperity they may linger in business for a long time whereas in times of adversity they disappear, generally by becoming insolvent; and the rate of their disappearance is in proportion to the acuteness of the depression. And the low number of insolvencies in farming as in other industries from 1934 onwards must not be entirely ascribed to the rise in the price level but at least in part to the thoroughness with which the depression weeded out the financially weak producers.

Some variation is shown in the ratio between the number of insolvencies in all businesses and those in farming but it remained fairly steady until 1934 after which there was an appreciable fall. The same is true of the total liabilities in the two categories. This seems to verify the observation based on the movement of index numbers that agriculture did not suffer to a greater extent than other industries during the depression years.

Failures in Allied Industries

Information is also available regarding failures amongst "cattle and other livestock dealers," but the number of dealers operating in the country is unknown, and moreover a large number of dealers are also part-time farmers. It is remarkable however that the number of failures amongst

dealers is so low. Downward movements in the prices of farm products may not be so severely felt by dealers as by producers as the period during which they hold the products is comparatively short. On a falling market they are in a position to contract their activities rapidly and reduce their commitments. Farmers on the other hand are obliged to incur expenditure on production many months before the final product is ready for sale, and as a result, declining prices frequently lead to losses. Average liabilities per case closely resemble those shown by farmers.

TABLE IV.

Failures in Allied Businesses.

Year.	*Cattle and other Livestock dealers.* No.	Liabilities.	Average per case.	*Smallholders, Poultry Farmers, Market Gardeners.* No.	Liabilities.	Average per case.
		£	£		£	£
1927	26	45,595	1,753	66	68,818	1,042
1928	29	66,087	2,279	77	93,160	1,210
1929	27	37,460	1,387	46	34,614	752
1930	27	29,710	1,100	44	35,244	801
1931	24	53,222	2,217	61	31,902	523
1932	37	70,977	1,918	74	78,417	1,059
1933	37	58,647	1,585	68	66,289	974
1934	28	41,559	1,484	61	46,411	761
1935	23	45,418	1,974	52	36,354	699
1936	19	25,621	1,348	58	53,488	922

The same general trend over the decade may be observed in another allied group, viz., "Small-holders, poultry farmers and market gardeners." These are classified together in the official returns consequently it is impossible to state which group suffered most severely. Taken together however the most unfavourable year was undoubtedly 1932. The average liability is appreciably lower in this class; it would be expected in fact that the average size of the business would be smaller than in the case of farmers. During the post-war period many persons have entered one or other of these businesses with but very limited funds. In many instances credit was obtained at comparatively high rates of interest and the depression years meant for such people an exceptionally heavy increase in their financial burdens. Many of the weaker ones have undoubtedly been weeded out and much capital has been lost in such ventures.

Failures in Comparable Industries.

In the official bankruptcy returns trades are grouped into 100 different classes with a miscellaneous group for those which cannot be satisfactorily classified. In normal times the number of failures in farming should bear some relation to those in other industries for which comparable data are available. It is extremely difficult however to find a period during which economic forces exert the same influence upon all industries. Certain trades may suffer depression or enjoy prosperity owing to some special factors which do not exert their influence over all industries to the same extent. Of all the different trades recorded, however, it is interesting that the number of failures amongst farmers was higher throughout the last decade than amongst those following any other occupation except builders and grocers.

Both the building and the grocery trades, particularly the former, are still run very largely as small private enterprises. Table V indicates that in so far as this test applies builders did not suffer unduly during the period of economic depression but rather during later years. This occupation however is exceptional in some respects and its welfare is not determined by the same factors as affect industries in general.

TABLE V.

Failures in the Building and Grocery trades.

Year.	*Builders.*		*Grocers.*	
	Number.	*Liabilities.*	*Number.*	*Liabilities.*
		£		£
1927	287	514,653	337	342,025
1928	326	694,461	369	375,800
1929	352	868,259	371	282,507
1930	350	854,155	370	347,677
1931	349	739,332	308	322,585
1932	353	837,946	368	318,149
1933	301	544,180	377	343,593
1934	392	1,256,912	368	303,491
1935	490	1,072,352	347	268,992
1936	511	1,180,197	382	388,985

The grocery trade on the other hand is to some extent subject to the free play of economic forces but in recent decades a considerable degree of protection has been afforded to the business. And the economic depression had very little effect upon the number of recorded failures. A very large proportion of the commodities handled are proprietary articles on which

definite retail margins are fixed. Distributors of such articles are in fact largely protected by the Trade Associations from some of the evil effects of a price decline. In the face of falling wholesale prices distributors' margins are maintained and so far as possible retail prices are only slightly reduced if reduced at all. This practice is now very common in the case of many branded articles as such a large number of Associations have been established in recent years with the object of protecting those engaged in particular trades. Price cutting in many lines has been very largely eliminated and in others considerably reduced. Distributors have therefore been placed in a very strong position and are well able to withstand a depression in trade. When demand falls off owing possibly to the declining purchasing power of the community and a reduction of the retail price is really inevitable, a corresponding reduction in the wholesale price is made. Retail margins are therefore largely maintained at a definite figure irrespective of movements in the general price level. Under such conditions the effects of a depression may not be very heavily felt by certain classes engaged in the distributive trade as the incidence of a price fall is passed backwards step by step towards the producer.

Farming Failures in Wales.

The number of failures amongst farmers in Wales over the last decade has shown the same general trend, the maximum

TABLE VI.

Farming Failures in Wales (including Monmouth).

	Farmers and Graziers.			*Smallholders, Poultry Farmers and Market Gardeners.*		
Year.	*No.*	*Liabilities.*	*Assets.*	*No.*	*Liabilities.*	*Assets.*
		£	£		£	£
1928	36	42,791	16.616	5	1.660	931
1929	27	22,299	10,126	—	—	—
1930	29	34,398	6,459	1	124	31
1931	18	20,702	7,027	2	548	160
1932	34	11,303	9,270	1	172	39
1933	42	35,451	11,420	3	1,544	700
1934	29	17,058	3,880	1	439	62
1935	19	17,868	3,167	1	128	25
1936	10	5,111	1,419	1	542	25
1937	17	11,182	3,494	—	—	—

being reached in 1933. On the whole, however, the business units in Wales are smaller than those in England and the organisation of farming is somewhat different. The family farm predominates in the Principality and the number of employees on the average is comparatively small. This form of organisation offers considerable resistance to unfavourable commercial conditions and can withstand periods of adversity remarkably well.

It is not implied, however, that those who are engaged in family farming do not suffer equally with others during an economic depression. In view of the fact that wages are not regularly paid to members of the family who work on the holdings, a considerable proportion of the annual revenue should be accumulated. During comparatively favourable times an appreciable amount of the income obtained, which under other systems may be utilised in the payment of wages, is set aside possibly for ultimate distribution when members of the family commence in business on their own account. When times are bad, however, the fund may be drawn upon to meet losses in current trading. Any business run on such lines may be conducted at a loss for several years without becoming insolvent or in fact without any indication being given that there is diminution of capital. The rise in wages of labour compared with pre-war days has had comparatively little effect upon the family farm system of Wales. On the whole in fact the cash outlay on hired labour does not exceed about 20 per cent. of the direct expenses.

The system of farming generally pursued also serves to protect the businesses against the evil effect of sudden downward movements of prices. Mixed farming which involves the combination of several different enterprises is really a very effective method of insurance against unfavourable economic conditions. When the price of one commodity shows a serious fall that of another may remain quite favourable and thus act as a compensating factor with the result that revenue is not seriously depleted. Farmers who specialise, on the other hand, may in certain periods make comparatively high profits and in others, when the market is unfavourable, suffer heavy losses. This system is not inherently self-insuring unless a very long period is allowed. And during the last decade or so the depression in many branches of farming has undoubtedly had a more serious effect upon some specialised producers than upon those who follow a system of mixed farming.

Normal Expectation of Losses.

In Table VII the number of failures per 10,000 farmers is given and it is apparent that in Wales the expectation of bankruptcy is much lower. For the purpose of calculating this ratio the total number of farmers in England and Wales is assumed to be 240,000 and in Wales 40,000. The number from which the failures are drawn and reported in the bankruptcy statistics would probably be less than this, as it is possible that many of the smaller businesses could become insolvent without being publicly reported. Cases of very small businesses where the expense of the recovery of the debt is not covered by the assets are not reported and the results do not become publicly known.

TABLE VII.
Proportion of Failures.
(No. per 10,000 farmers).

Year.	*England and Wales.*	*Wales.*
1928	19	9
1929	14	7
1930	14	7
1931	21	6
1932	25	8
1933	18	10
1934	12	7
1935	9	5
1936	9	2

It is extremely difficult to estimate the capital lost in farming, in fact no accurate calculation can be made as considerable sums may be lost even though the businesses may not be reduced to a state of insolvency. Many farmers after a number of years of unsuccessful business may decide to realise what assets there may be left and to leave the industry. In such cases, and there are undoubtedly many of them, a large proportion of the original capital invested may have dwindled away, but no data are available to indicate the magnitude of such losses. And moreover in the bankruptcy cases reported the total liabilities recorded do not indicate the exact sum of capital loss, nevertheless this figure may be compared with the capital invested in agriculture in order to estimate the proportion lost in consequence of insolvencies.

Farming capital may be divided into two classes (a) that invested in agricultural land, farm houses, cottages and buildings let with the land and (b) tenant's capital which includes live and

dead stock, tenant right and cash available to meet current outgoings. It was estimated in 1925 that the capital value of agricultural land and fixtures in England and Wales amounted to £815 million. An estimate of comparable assets in 1931 gives a reduced figure of £645 million.[5] This shows a fall of 21 per cent. over a comparatively short period.

Tenants' capital in 1925 stood at £365, but had fallen to £280 by 1931, a decline of 23 per cent. Although this reduction was due in a large measure to the fall in values in consequence of the depression, it may partly be explained by the change in the nature of the agricultural industry. During this period the area of crops and grass fell by half a million acres and the number of holdings in the country also declined with the result that the area of the others particularly the pasture farms expanded.

A comparison between the total liabilities shown by the reported failures and the total of tenants' capital gives the nearest possible approximation to the rate at which capital has been lost in recent years.

TABLE VIII.

Capital Losses (Per £10,000 of tenants' capital).

Year.	*England and Wales.* On 1925 Capital.	*England and Wales.* On 1931 Capital.	*Wales.* On 1925 Capital.	*Wales.* On 1931 Capital.
	£	£	£	£
1928	25	33	31	44
1929	20	27	17	22
1930	28	30	27	35
1931	31	40	16	21
1932	39	51	32	42
1933	24	38	28	37
1934	15	20	14	18
1935	11	15	14	18
1936	11	15	4	6

In general it appears that the normal expectation of insolvencies amongst farmers in England and Wales is about 300 a year. There may be variations up to about 500 during comparatively unfavourable years whereas the number may fall to about 200 during years of business recovery. Individual years may of course show fluctuations in excess of these limits but this would probably be due to exceptional circumstances. On the whole the proportion of insolvencies in farming during the last

[5] See Reports on Agricultural Output of England and Wales, 1925 and 1930-31.

decade has been comparatively steady, and on the average the number has been somewhat below two per thousand whilst in Wales the ratio has been appreciably lower. The proportion of capital lost is much the same between the two countries and on the average amounts to about £8 per £1,000 of tenants' capital invested in the industry.

APPENDIX.

Failures amongst Farmers in England and Wales.

Year.	*Number.*	*Index**	*Index of Agricultural Prices.*
1911	305	—	—
1912	336	100	100
1913	326	—	—
1914	189	58	101
1915	132	41	127
1916	78	24	160
1917	65	20	201
1918	30	9	282
1919	33	10	258
1920	44	13	292
1921	285	88	219
1922	403	125	169
1923	482	146	157
1924	360	112	161
1925	368	114	159
1926	342	106	151
1927	478	148	144
1928	462	143	147
1929	345	107	144
1930	350	108	134
1931	497	154	120
1932	600	186	112
1933	428	133	107
1934	288	89	114
1935	224	69	117
1936	215	66	122

* Index: Average 1911-13 = 100.

FOOD DISTRIBUTION IN THE RHONDDA VALLEY.

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Introduction.

The problems of distribution of the necessities of life and the associated needs of human beings are receiving considerable attention at the present time. Problems relating to food distribution have occupied the attention of a number of Committees and Commissions since the War and a large part of present-day trend of policy with regard to the marketing of food products can be traced to the work and recommendations of the Linlithgow Committee.[1] But the demand for information about the distributive industry as a whole is of comparatively recent growth and so far very little is known about it.

Rhondda Urban District.

A study of the annual reports of the Medical Officer of Health for the Rhondda Urban District from 1920 to 1935 gives a record of change during a time when the main industry of the area was experiencing many vicissitudes and its people had to adopt what measures they could to benefit from State and voluntary action to mitigate the worst results of their predicament in a situation of serious industrial depression. But there are other forces as well as industrial changes causing a certain amount of dislocation in the social fabric and some discussion of all these is necessary in order to put the problem into proper perspective.

Population Changes.

It is estimated that the Rhondda Urban District lost over 33,000 people during the years 1924 to 1935, and it is established that the loss was in the main attributable to young people leaving the district owing to continued depression in the main industry of coal mining. The occupational census (1931) shows that 68.9 per cent. of the male population of 16 years and over was normally engaged in coal and shale mining, 6.5 per cent. in commercial pursuits and the remainder in other occupations.

[1] Reports of Departmental Committee on the Distribution and Prices of Agricultural Produce, 1923 and 1924.

At this time nearly 24 per cent. of those occupied or seeking an occupation were unemployed. Again nearly 70 per cent. of juveniles (14-20 years of age) were "occupied" in the mining industry and 10.7 per cent. of juveniles were unemployed. The heavy dependence of the people on coal mining coupled with the fact that the industry was declining caused a marked change in age and structure of households resulting in a net loss of numbers by migration of the most virile sections of the population.

> "This eflux from the Rhondda consists almost entirely of young men, who, owing to the continued depression in the coal mining industry, seek employment in other industrial districts, and of young women, who enter domestic or various professional services, so that there has been an increase in the proportions of the younger and older elements in the age distribution of the population as a whole, as compared with those obtainable when coal mining flourished in the district."[2]

The population was about 166,600 in 1921; showed fluctuations up to 167,900; and then showed a steady decline after 1925 down to 142,230 in the Census year 1931 and to 134,600 in 1935. The number of inhabited houses increased by about 600 between 1921 and 1925, then rose a little again to 1928, and afterwards showed a very slight tendency to decline. Numbers of persons per inhabited house increased while both population and houses were increasing in numbers up to 1925 but has since shown decline from 5.82 in that year to 4.70 in 1935.

Vital Statistics.

Numbers and estimated rates of births have been declining almost continuously since 1920; by 1935 the rate had fallen to little more than half what it was 16 years earlier. Numbers of deaths also declined but the death rate showed little change during the whole period. The "natural increase" of population (excess of births over deaths) which was 17.0 in 1921 was only 3.7 per thousand in 1935. This is a highly significant fact and one which must cause continued and great social and economic dislocation in the future. And not the least changes will be those in the numbers and characters of shops required to serve the people in the area.

With these changes in population shops are required to

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[2] Report of the Medical Officer of Health and School Medical Officer, 1935, page 17.

provide less of the special requirements of babies, infants and adolescents; and more of the special requirements of aged people, in so far as they have the purchasing power necessary to cover special requirements. But the population group for the time being has become more than normally an adult group, and the needs of adults are more than usually predominant in the determination of needs in retail distribution.

Rates and Rateable Values.

The rateable value of the area tended to fall from 1920 to 1936, but there were interruptions in the fall in some years during this period, notably in 1924, 1925, 1929 and 1930. Then in 1931 the derating of industrial properties under the Local Government Act, 1929, caused a drop of about one-third. The rateable value per head of the population at £3.98 in 1920 and £2.02 in 1935 shows the same falling trend. The general district rate increased from 7s. 4d. to 22s. 6d. in the £ which is a three-fold increase. Rateable values expressed per occupied house diminished. The wealth of the community in this area was showing a rapid and progressive decline.

This is the background against which a study of the trends of distribution of food and other things must be made.

Numbers of Shops.

Numbers of food shops, non-food shops and retail centres for sale of intoxicating liquors showed absolute increase up to 1924

Numbers of Shops.

Year.	*Food.*	*Non-Food.*	*Retailers of Intoxicating Liquors.*	*Total.*
1920	1,552	962	131	**2,645**
1921	1,720	995	130	**2,845**
1922	1,828	1,020	131	**2,979**
1923	1,833	1,032	132	**2,997**
1924	1,847	1,045	132	**3,024**
1925	1,804	1,011	132	**2,947**
1926	1,757	1,007	132	**2,896**
1927	1,783	1,003	132	**2,918**
1928	1,715	946	132	**2,793**
1929	1,635	915	131	**2,681**
1930	1,592	902	130	**2,624**
1931	1,568	878	130	**2,576**
1932	1,530	860	129	**2,519**
1933	1,497	853	128	**2,478**
1934	1,442	848	128	**2,418**
1935	1,363	838	127	**2,328**

while population was increasing. After that year all three types showed regular decreases to 1935 with the one slight exception of numbers of food shops in 1927. In that year there was a temporary increase in numbers of food shops but the decline in numbers was again continuous from that year to 1935.

Shops, Houses, and Population.

In considering the number of shops needed or likely to be found a number of conditions may be borne in mind. The first is that of changes in numbers of population, while the second will be that of their purchasing power, and the third will be the number of inhabited houses and their scatter or the distance between house and house or house and shops. The last condition may be qualified by provisions for ordering and for delivery, but in a district like that of the Rhondda, even though residences and population are fairly concentrated, it seems to be important and not to have been qualified to any considerable extent by developments in delivery.

Numbers of both food and non-food shops in relation to population showed some increase up to 1924 when number of houses and population were both increasing. In 1920 there was one food shop for every 106 persons as compared with one for every 91 persons in 1924. There was one non-food shop for every 172 persons in 1920 as compared with one for every 161 persons in 1924. At this period the number of shops in relation to inhabited houses showed practically no change. Thus it appears that while population was increasing there was a tendency to increase the number of shops as the number of houses increased, although this brought a declining ratio of number of persons per shop because of the decline in number of persons per inhabited house.

The worst conditions were reached about 1927 when the number of persons per food-shop was 89 and that for each non-food shop was 159. At the highest points there were 106 persons per food shop and 172 persons for each non-food shop in 1920.

While there was one shop for each 10 houses in 1925 there was only one for each 13 in 1935. Number of houses per food shop rose from about 15-16 in 1925 to 20-21 in 1935, while numbers of houses for each non-food shop rose from 28-29 in 1925 to 33-34 in 1935. Thus the general changes in population and households consisted of a decline in the population, with number of inhabited

houses nearly constant with slight tendency to decline, and a marked fall in the number of persons per house. The effect of these changes, together with industrial uncertainty, unemployment, and diminishing purchasing power were somewhat different in two periods before and after 1927. It is estimated that the population increase stopped in 1924 but total numbers of shops and of food shops continued to increase up to 1927, and non-food shops continued to increase up to 1925. During this period it appears that people were still opening businesses, hoping for livelihoods therefrom, and that they may have been tempted thereto partly by the increase in the number of inhabited houses and to some extent by the increased scatter of residences.

This condition, however, proved to be a false guide, because the density of population was falling with increase of houses. And although there is no exact measure of any such change it is practically certain that average purchasing power per house (if not per head) was diminishing.

Relations between Numbers of Persons. Inhabited Houses and Shops.

	Food.		*Non-Food.*		*Total.*	
Year.	*Persons per Shop.*	*Houses per Shop.*	*Persons per Shop.*	*Houses per Shop.*	*Persons per Shop.*	*Houses per Shop.*
1920	106	—	172	—	66	—
1921	97	16	167	28	61	10
1922	92	—	164	—	59	—
1923	92	—	163	—	59	—
1924	91	—	161	—	58	—
1925	93	16	166	28	59	10
1926	92	16	161	28	59	10
1927	89	16	159	29	57	10
1928	90	17	163	30	58	11
1929	94	18	167	31	60	11
1930	92	18	168	32	59	11
1931	91	18	162	33	58	12
1932	92	19	164	33	59	12
1933	93	19	163	34	59	12
1934	95	20	162	34	60	13
1935	99	21	161	34	61	13

Types of Shops.

The proportion of shops dealing in food products has been 60.6 per cent. over the period of 16 years, non-food shops amounting to 34.6 per cent. of the total and places for retail sale of intoxicating liquors 4.8 per cent. Taking the period as a

whole, however, there was some departure from this average position in all types. Food shops tended to become relatively less important towards the end of the period and the other two groups gained somewhat.

The distribution of the different types of shops within the total is best shown by the following summary.

Types of Shops (Per cent. of Total).

	Average of 16 years.	*Highest.*	*Lowest.*
Non-food ...	34.6	36.1	33.9
Intoxicating Liquors ...	4.8	5.5	4.3
Food ...	60.6	61.4	58.5
Food.			
(1) Butchers* .	6.1	6.4	5.8
(2) Confectioners, etc. ...	9.2	10.9	6.4
(3) Milk ...	1.1	1.4	0.8
(4) Fish and Chips ...	5.6	6.1	5.1
(5) Greengrocers ..	8.6	10.4	6.7
(6) Grocers ...	10.8	11.7	10.1
(7) & (8) Refreshment Houses	4.1	4.5	3.8
(9) Sweets ...	15.1	15.9	14.4

* For full description see below.[3]

Types of Shops, Population and Households.

When average numbers of households and population available for purchasing from each food shop are set out, it is seen that the sweet shops, provision merchants and greengrocers rely on a low average number of possible customers. The position with regard to butchers, confectioners and bread dealers, fried fish and chipped potato shops and refreshment houses shows a greater spread over population while dairy products and milk shops and restaurants and cooked meat shops have a particularly high average number of potential customers.

The changes which have occurred in the numbers and types of shops during the period under consideration is interesting and informative when related to changes in population. There were fewer butchers per 100,000 people in the area in 1920 than at

*[3] KEY TO TYPES OF SHOPS.

(1) Butchers.
(2) Confectioners and Bread Dealers.
(3) Dairy Products and Milk Shops.
(4) Fried Fish and Chipped Potatoes.
(5) Greengrocers, Fruiterers and Florists.
(6) Grocers and Provision Merchants.
(7) Refreshment Houses and Temperance Bars.
(8) Restaurants, Cooked Meat Shops, Coffee Rooms and Oyster Bars.
(9) Sweet Shops.

Houses and Persons per Shop 1920-35.

Type.	*Average Number of shops.*	*Inhabited Houses per Shop.*	*Population per Shop.*
Non-Food ...	945	30	168
Intoxicating Liquor ...	130	220	1,189
Food ...	1,654	17	98
Food.			
(1) Butchers ...	166	172	931
(2) Confectioners, etc. ...	252	118	618
(3) Milk ...	29	986	5,380
(4) Fish and Chips ...	152	188	1,017
(5) Greengrocers ...	236	121	655
(6) Grocers ...	294	97	526
(7) & (8) Refreshment Houses, etc. ...	113	253	1,367
(9) Sweets ...	412	69	375

any time since that year and the highest figures were recorded in 1928 and 1932. In the intervening years a slight cyclical movement in numbers has been occurring and numbers were declining in 1935. Measured in the same way, numbers of confectioners and bread dealers increased from 102 in 1920 to 192 in 1931. Since that time a decline has occurred to 172, but that figure is 70 in excess of the number for 1920.

Dairy products and milk shops were more important as regards numbers in the first decade of the period considered, especially towards the middle of it, than they have been since; and in the present decade the number has tended to decline. But it should be made clear that this class does not include itinerant vendors of milk, whether producing or purchasing retailers.

Numbers of fried fish and chipped potato shops tended to increase up to the period 1926-31. A decline in numbers occurred after that time. But there were more of these shops in relation to numbers of population in 1935 than in 1920 despite the declining trend of numbers.

The maximum number of greengrocers, fruiterers and florists' shops occurred in 1922 and the decline in numbers has been continuous since that time; the lowest figure for 16 years was recorded in 1935.

Numbers of shops dealing in groceries and provisions increased with the exception of a few years from 1920 to 1934. And the recorded figure for 1935 is higher than any in the previous decade.

Refreshment houses and temperance bars showed some tendency to increase in numbers during the first decade but since that time a small decline has occurred and on balance there has been little change in numbers. The position with regard to restaurants, cooked meat shops, coffee rooms and oyster bars shows some decline.

Numbers of sweet shops were greater in 1922-24 than they have been since and the general trend is downward.

Non-food shops and places for retail of intoxicating liquors have tended to become increasingly important during the 16 years under consideration. But the degree of change in numbers is again very small indeed.

The changes in the general categories—food, non-food, and intoxicating liquor shops—are relatively small. More marked changes have occurred inside the food group

Types of Food Shops.
(Per Cent. of Total)

	Average 16 years.	*Highest.*	*Lowest.*
(1) Butchers ...	10.0	10.9	9.5
(2) Confectioners, etc. ..	15.2	17.7	10.9
(3) Milk ..	1.7	2.3	1.3
(4) Fish and Chips	9.2	10.0	8.8
(5) Greengrocers ..	14.3	17.3	11.3
(6) Grocers ..	17.8	19.7	16.7
(7) & (8) Refreshment Houses etc. ...	6.9	7.1	6.3
(9) Sweets ..	24.9	26.1	23.5
Total ..	100.0		

Meat shops have not shown any marked changes; numbers of confectioners and bread dealers have risen from 10-13 per cent. of the total food shops from 1920-25 to 16-17 per cent. since those years. In the case of greengrocers, fruiterers and florists the change has been in the opposite direction for numbers which represented 15-17 per cent. of total food shops 1920-25 have fallen to 11-12 per cent. for the last five years. Grocers tend to constitute an increasing proportion of the shops, but there is no marked trend in any of the remaining groups.

The changes in numbers of shops relative to the numbers of persons to be served mainly arise from differences in rates of closing shops as population declined. Amongst the food shops only confectioners and bread dealers—mainly bread dealers

—show numbers of shops opened in excess of numbers closed, and this positive balance occurred in the early part of the period. On the other hand, the class showing the largest decline in relation to population, greengrocers, etc., shows numbers of shops closed greatly in excess of numbers opened.

These two marked changes, increase in bread dealers and decline in greengrocers, are almost certainly directly connected with changes in standards and conditions of living As purchasing power per head of population declined there would be relatively heavier expenditure on bread and there may have been an absolute increase in expenditure per head. The consumption of purchased fruit and some other greengrocery supplies would almost certainly decline with purchasing power, but in this case the shopkeepers had to meet some competition from increased cultivation of allotments in the first place for home supply but also to some extent for sale of produce to neighbours and acquaintances.

Turnover of Shops.

Under normal circumstances a considerable turnover of retail business must occur each year from such causes as deaths, retirements, removal to other areas, failure to earn satisfactory profit, or insolvency. The normal rate of turnover is unknown so it is not possible to judge the effect of the special conditions in the Rhondda on the opening and closing or transfer

Turnover of Shops (1920-1935)
Actual Numbers.

Type.	*Total Number.*	*New Businesses Registered.*	*Total Number Closed.*	*Balance.* +	*Balance.* —
Non-Food	15,115	1,827	1,918	—	91
Intoxicating Liquor ...	2,087	329	331	—	2
Food	26,466	4,214	4,330	—	116
Food :					
(1) Butchers	2,663	283	305	—	22
(2) Confectioners, etc. ...	4,036	744	672	72	—
(3) Milk	457	78	85	—	7
(4) Fish and Chips ...	2,432	630	632	—	2
(5) Greengrocers ..	3,769	553	646	—	93
(6) Grocers ...	4,710	314	338	—	24
(7) and (8) Refreshment houses, etc. ..	1,809	366	367	—	1
(9) Sweets	6,590	1,246	1,285	—	39
Total	43,668	6,370	6,579	—	209

of retail businesses. But there can scarcely be any doubt that these special conditions have caused many changes. The only class in which new registrations have been in excess of numbers closed is that of confectioners and bread dealers, and these all occurred in the early part of the period. In all other classes, excess of closings over registrations occurred chiefly after 1928. Taking all food shops together there were excesses of registrations over closings from 1920 to 1924, and excess of closings over registrations in every other year except 1927.

Approximate Average "Life" per Business (Years).

Non-Food	8—9
Intoxicating Liquor	6—7
Food	6—7
All Shops	6—7
Food	
(1) Butchers	9—10
(2) Confectioners, etc	5—6
(3) Milk	5—6
(4) Fish and Chips	3—4
(5) Greengrocers	6—7
(6) Grocers	15—16
(7) & (8) Refreshment Houses, etc	5—6
(9) Sweets	5—6

The approximate average number of years which shops of different types stay under the control of one person or firm is surprisingly short, but again allowance has to be made for the special conditions.

Turnover of Shops.

(Annual Averages 1920-35).

Type.	*Average Number Closed.*	*Average Number Opened.*	*Rate of Turnover.*	
			Closings.	*Openings.*
			%	%
Non-Food ...	120	114	12.7	12.0
Intoxicating Liquor ...	20	21	15.3	16.1
Food ...	271	263	16.4	15.9
Food.				
(1) Butchers ...	19	18	11.4	10.8
(2) Confectioners, etc.	12	47	16.6	18.6
(3) Milk ...	5	5	17.2	17.2
(4) Fish and Chips ...	40	39	26.3	25.6
(5) Greengrocers ...	40	34	16.9	14.4
(6) Grocers ...	21	20	7.1	6.8
(7) & (8) Refreshment Houses, etc. ...	23	22	22.1	19.1
(9) Sweets ...	81	78	19.6	18.9
Total ...	411	398	15.0	14.6

The relative stability of the butchers' and the grocers' businesses stands out very clearly, while the quick change-over of fried fish and chipped potato shops is also remarkable. The relative stability of non-food shops should also be noted.

Shops and Employment.

Statements are frequently made that the costs of distributing the things which consumers need are becoming higher because of the extra services they require and the necessity of employing more labour to carry out these services. This is particularly true when the hours of labour are restricted, for the extra services required have to be given in a shorter working day and in the absence of any increase in the efficiency of labour the amount of it required must tend to increase. Where increase in rates of wages also accompanies these changes the cost of distributing a given amount of product must increase. The available records do not give all the information but the trend of hired employment by types of shops is shown. A summary of the general position for the years 1920-25 and 1930-35 and for the whole period is given in the following Table.

Proportion of Shops with Hired Assistants. Per cent.

Type.	*1920-25.*	*1930-35.*	*16 Years.*
Non-Food ...	45.3	41.8	42.8
Intoxicating Liquor ...	51.5	77.5	61.7
Food ...	32.8	33.0	32.1
Food.			
(1) Butchers ...	59.9	79.4	69.5
(2) Confectioners, etc ..	26.8	17.8	20.7
(3) Milk ...	15.1	26.2	19.8
(4) Fish and Chips ...	38.9	20.4	26.3
(5) Greengrocers ...	25.1	27.0	24.7
(6) Grocers ...	70.9	71.2	70.3
(7) & (8) Refreshment Houses, etc. ...	41.0	31.3	34.2
(9) Sweets ...	2.5	1.1	1.7

During the period 1920-25 almost 60 per cent. of the butchers employed assistants while in the years 1930-35 this proportion had increased to 79 per cent. In fact, there was a continuous upward trend throughout the entire sixteen years.

Confectioners and bread dealers showed exactly the opposite tendency. Fewer shops used hired labour towards the end of the last decade than at the commencement of it. An increasing proportion hired assistants in the first half of the present decade.

Dairy products and milk shops showed a fairly steady position as regards the proportion employing assistants from 1920 to 1931, and a big increase in 1932 which was maintained to 1935.

The proportion of fried fish and chip potato shops employing assistants has shown some decline in the last 16 years with a tendency to decrease in the middle of the period but some recovery towards the end of it. Employment of assistants in greengrocers and florists' shops has also increased slightly.

A high proportion of grocers and provision merchants have always relied on hired labour for assistance. While there was some tendency for the percentage employing assistants to decline about the middle of the period some recovery is shown since 1931.

There has been a heavy fall in the proportion of shops in the classes refreshment houses and temperance bars, and restaurants, cooked meat shops, coffee rooms and oyster bars employing assistants and the same observation is true of sweet shops. But the first of these classes shows a much heavier reliance on hired assistance than the second and third classes.

The total figures for all food shops show that round about a third of them employ assistants and that there was only a small degree of change-over during the sixteen years 1920-35. Only in the years 1926, 1927, 1928 and 1931 did the ratio fall below 30 per cent.

The most outstanding features of employment in food shops are the heavy dependence of butchers and grocers and provision merchants on employed assistants; the increase that has occurred with regard to the former; the recent increase in the ratio of dairy shops which rely on hired labour and the almost stationary or declining position of all other types of food shops in respect of employment of hired labour.

The trend of the same ratios for non-food shops is downwards while those for places for retail sale of intoxicating liquors is upwards. The net position of all shops shows little change throughout the period except for a slight falling tendency about the years 1925-28.

Assistants per Shop.

The data available covers only hired assistants in shops, and does not deal with total amount of labour engaged in retail distribution. The number of hired assistants depends not only on the size of shop or business but often partly on the number

of relatives, mainly sons or daughters, of the operators available for work therein. It might perhaps have been expected that with a fall in the birth rate the number of hired assistants would increase, but the special fall of the birth-rate in the Rhondda has not continued long enough to have such effect.

Numbers of hired assistants (per shop) employed by butchers increased steadily during the period and those employed in grocers and provision merchants shops were highest at the beginning, middle and end of the period 1920-35. Substantial decline in numbers of hired assistants employed occurred in the type bread dealers and confectioners while a variable trend tending to follow a downward direction is shown by shops of the dairy types. Little significant change in the trend of employment of hired assistants was shown by the other shops in the food group. Numbers of hired workers employed have tended to increase in the food group as a whole and the same observation holds for shops in the non-food group.

Assistants per Shop.

Type.	*Average.*	*Highest.*	*Lowest.*
Non-Food ...	2.32	2.55 (1935)	2.18 (1922)
Intoxicating Liquor ...	1.65	3.39 (1920)	1.33 (1933)
Food ...	2.41	2.59 (1931-5)	2.33 (1921-3)
Food.			
(1) Butchers ..	1.77	1.99 (1931)	1.54 (1922)
(2) Confectioners, etc. ...	1.48	1.74 (1921)	1.27 (1926)
(3) Milk ...	1.44	1.75 (1920-1)	1.16 (1924)
(4) Fish and Chips ...	1.31	1.53 (1920)	1.11 (1926)
(5) Greengrocers ...	1.42	1.69 (1920)	1.14 (1928)
(6) Grocers ...	3.82	4.07 (1920)	3.70 (1932)
(7) & (8) Refreshment Houses, etc. ...	1.64	2.23 (1929)	1.29 (1934)
(9) Sweets ...	1.21	1.75 (1934)	1.00 (1925-9)

Thus the net position with regard to hired employment in food shops taking into account the trend of numbers of shops employing assistants and the average number of those employed in each shop was that more employment of this character was provided. Leaving out those food shops averaging less than 10 per cent. of the total of such shops it might be said that employment of hired labour increased substantially in butchers shops and slightly in provision merchants shops. Marked decline occurred in those selling bread and confectionery, fish and chip potatoes and sweets.

Conclusions.

The Rhondda Urban District has been losing its population at a high rate by migration and the natural increase has shown almost continuous decline.

Depression in industry and alteration in methods of rating have added considerably to the burden of the rates. The weight of local taxation has become exceedingly heavy on consumers directly and even indirectly dependent on the coal mining industry, and also on distributors selling in a market very much affected by curtailment in the aggregate spending power of the area.

Shopkeepers have read the signs of the times in their own ways. Numbers of shops in relation to inhabited houses have declined. But average size of households declined at the same time and thus little change occurred in the average numbers of persons served per food shop. Purchasing power of the households declined very appreciably. Thus numbers of inhabited houses became altogether too insensitive as an index of commercial opportunities for shopkeepers and the domestic needs of consumers.

There was little change in the ratio of food shops to total shops. Changes occurred in the relative quantitative importance of those in the food group. Relative increases were shown by bread dealers and grocers shops; others were stationary or declining. The relation between the separate shop types in the food group and population showed practically the same sort of trend.

Records of registrations and closings of shops illustrate the degree of change which has occurred and this has been high for practically all types in the food group. Only bread shops and refreshment houses showed an average positive position over the whole period and this arose on account of heavy positive balances prior to 1927. Since that year there were negative balances shown by practically all types of shops. Two periods of remarkable liquidation have occurred. One commenced in 1928, which was the year in which inhabited houses reached maximum numbers, four years after the peak in population and two years after the General Strike. The other set in during 1934 about three years after the financial crisis.

The average rate of turnover of food shops by types showed that grocers were the most stable and these were followed by butchers. All other types were much less stable particularly fish

and chip potato shops which showed on the average complete change every four years. Shops in the non-food group showed the greater stability.

Changes occurred in employment in shops, some types tending to employ more labour and others less. The changes occurred in two ways. Some important types in the food group employed more labour per shop and more shops in the group employed assistants. Butchers and grocers and provision merchants employed more hired labour. Bread dealers and confectioners particularly tended to employ much less labour while the hired labour position in the other food shops showed no marked change. Shops in the non-food group employed less labour and places for retail sale of intoxicating liquors relied to a greater extent on hired labour as the period advanced. But these tendencies of hired labour to rise and fall must be influenced by the amount of family labour available and this is important in some kinds and types of shops. The net employment position is therefore subject to this qualification.

The record of change shown demonstrates the attempt made by retailers as a whole to modify the quantitative character of the distributive machine in response to social changes. They have managed to do this with varying degrees of success in the various types of shops. As regards some types of food shops the distributive process seems to have become more expensive because a greater amount of hired labour is employed, while shops have shown on the average little tendency to serve more customers. This feature is particularly true of butchers' shops and grocers and provision merchants. And the latter in particular have always relied heavily on hired labour.

This seems to indicate that consumers are demanding more services than formerly. How long these new demands can be met while population declines is a tremendously difficult question to answer. It is certain, however, that so long as numbers of customers per shop continue to decrease and the total employment (hired and family) per shop rises somebody's standard of living must suffer. Consumers may have to accept less service, shopkeepers may have to relinquish business or continue at a lower rate of remuneration, hired employees may have to accept lower wages per unit time worked or producers of the goods shopkeepers sell may have to accept lower prices. And when this last position is attained the producers of farm products and therefore of the goods food shops sell will want to know what possibilities there

are of lowering costs of distribution. It is clear that from a purely quantitative standpoint, at any rate, the increase of efficiency in food distribution in this area under the special and difficult conditions prevailing since 1920 has been practically at a standstill. But the distribution of food has important, perhaps all important, qualitative aspects and an investigation of the trend with regard to these would be necessary in order to come to a final decision as to desirable and possible degrees of change in food distribution in all its varied aspects.

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EXPENDITURE OF UNEMPLOYED AND EMPLOYED HOUSEHOLDS:

A STUDY OF SOME YEARLY BUDGETS

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Previous studies of household budgets in Great Britain have failed to provide information on many important points. Records have usually been made for short periods like a week or a month, and have not shown the seasonal variations in expenditures which in a general way are known to exist. They have not given any indication of changes in expenditures in the same households with changes in prices. And they have not shown differences between households mainly or wholly dependent on wages and those wholly or mainly dependent on such sources of income as unemployment insurance benefits, public assistance and pensions.

It is not an easy matter to secure a supply of household budgets covering a year's receipts and expenditures, and the

Department* therefore does not feel any occasion for apology in presenting the records of eight households which are given below. On the contrary, the Department must consider that it has been greatly favoured by the confidence and willing assistance of the co-operating households.

With such limited access to family records as exists it is not possible to choose families containing members of working age which have no income from wages, and, on the other hand, it is also difficult to choose families having no other sources of income. Of the eight families whose budgets are dealt with below, four are of the "unemployed" type with only about one-twentieth of income from wages, and four are of the "fully employed" type with only about 2½ per cent. of total income from unemployment insurance.

The families in the "unemployed" group, as is fairly commonly the case, were slightly larger than those in the "employed" group. The larger families had incomes averaging about 36s. 5d. per week with which to maintain just over four persons, while the smaller families had incomes averaging about 97s. 4d. per week for a little less than four persons. The unemployed families so arranged their yearly budgets that they spent practically all they received, while the other families had a surplus over the expenditures listed which amounted to about 4 pence per head a week over the year. These simple facts show the general economic positions of two small groups of families but the full income conditions are shown in Table I.

TABLE I.

Amount and Sources of Income (12 months).

	Unemployed.		*Employed*		*Total.*	
Persons per Household.	4.25		3.87		4.06	
Income per Person per month.	£1 17 1		£5 8 10		£3 1T 4	
	£ s. d.	%	£ s. d.	%	£ s. d.	%
Wages or Salaries	20 15 4	5.5	911 14 0	90.0	932 9 4	67.0
Unemployment Insurance ...	239 0 0	63.1	23 16 0	2.1	262 16 0	18.9
Public Assistance	79 2 0	20.9	—	—	79 2 0	5.7
Pensions ...	23 5 4	6.2	—	—	23 5 4	1.7
Other ...	16 9 0	4.3	77 1 0	7.6	93 10 0	6.7
	378 11 8	100.0	1012 11 0	100.0	1391 2 8	100.0

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In the unemployed group slightly under two-thirds of income was received by way of Unemployment Insurance and about one-fifth from Public Assistance. Wages, which accounted for 5.5 per cent. of the total, represented the sum received by one of the households during the course of two winter months. Pensions, at 6.2 per cent., were received by just one household, and income from " Other " sources represented the proceeds of sub-letting, which was again received by a single household. The monthly distribution of total income remained remarkably even throughout while numbers of persons remained unchanged. In fact the only variation in total income and therefore in income per person was a very slight increase during the two months when one of the heads was temporarily employed But income per person was then only 3 shillings above the average for the year.

In the employed group wages or salaries accounted for 90 per cent. of total income. The small proportion received from Unemployment Insurance was spread over the seven months or so during which one of the younger members of one of the households was out of employment, while the remainder was received from sub-letting. Over the whole year the income received by the employed group showed somewhat greater variation than did that of the unemployed group while there was also some variation in numbers of persons. Income per person per month varied from £4 15s. 0d. in August to £6 2s. 0d. in April.

Points which may be of interest in the study of these small groups of budgets covering a whole year are the proportionate distribution of income in the unemployed and employed groups, seasonal distribution of expenditure and the effects of changes in prices on different group expenditures. The year in this case ran from July, 1936, to June, 1937, and as prices were rising during the year expenditures have been divided into quarterly and half-yearly periods.

The only group of expenditures which show any marked seasonal change is that of fuel and lighting, and even here the increased consumption during the winter period may be masked by anticipation of requirements, especially of fuel, or by delayed payment. In other cases, food expenditures remain at much the same level through the year, except for changes in prices; expenditures on clothing and household equipment are somewhat spasmodic; and generally the different groups of non-food expenditures tend to balance each other so that quarterly expenditures are relatively even.

Families which suffer unemployment for short periods usually maintain their food expenditures near to the normal level, but when unemployment continues all such families as desire to maintain their social standing have to endeavour to make expenditures in all the normal groups, and to balance expenditures for a minimum degree of satisfaction of all their requirements, physiological and social.

TABLE II.

Relation between Food and Non-Food Expenditure.

Period.	*Unemployed.*		*Employed.*		*Total.*	
	Food	*Non-Food*	*Food*	*Non-Food*	*Food*	*Non-Food*
	%	%	%	%	%	%
July-September, 1936 ...	45.0	55.0	40.5	59.5	42.0	58.0
October-December, 1936	43.3	56.7	37.1	62.9	38.9	61.1
July-December, 1936 ...	44.2	55.8	38.6	61.4	40.3	59.7
January-March, 1937 ...	45.8	54.2	39.0	61.0	41.1	58.9
April-June, 1937 ...	48.2	51.8	35.7	64.3	39.4	60.6
January-June, 1937 ...	47.0	53.0	37.4	62.6	40.3	59.7
Year ...	45.6	54.4	38.0	62.0	40.3	59.7

The analysis of the food and non-food expenditures by quarterly periods shows for the unemployed group a rise in the percentage spent on food. This was due not to any reduction of income, but mainly to increases in prices of foods. On the other hand, the food expenditure of the employed group showed a tendency to decline in proportion, due to increasing expenditure on non-food groups with the realisation that resources were available for purchase of the secondary necessaries. The general expenditures of the unemployed group, as will be seen later, have been designed to give as nearly as possible the maximum satisfactions. While it may appear that 46 per cent. is a rather low proportion of income for unemployed households to spend on food, among these households certain non-food items over and above the basic requirements of shelter, fuel and clothing have become of the nature of conventional necessities. Members of this section of the community have realised that the retention of some of the habits which were part of their normal expenditure when they were in employment acts as a safeguard on their present standards. But the more detailed analysis of this non-food expenditure which will be made at a later stage will show that the income which they received did not allow of many "frills." The proportionate expenditure on food was lowest in

the three months October-December and highest from April-June. That for the second half-yearly period was higher than that for the first, but for the employed group the reverse was the case. For the eight households, however, the proportions were identical, although there were slight variations in the different quarterly periods. Analysis of the expenditures on foodstuffs shows fairly steady policy in both groups, except for the change in prices, over quarterly periods. In the case of the unemployed group, however, further analysis shows that monthly expenditures per head on foods varied between 14s. 7d. in October, 1936, and 18s. 2d. in June, 1937. From the constitution of the families, the employed group would tend to show greater expenditures on foodstuffs per head, but there cannot be any doubt that low expenditures on foods in the unemployed group is due to the dual cause of poverty and the necessity of maintaining expenditures on the non-food groups over long continued periods of low incomes.

Expenditures on foodstuffs by the employed group showed somewhat similar trends. Increase in the value of purchases is evident but the heaviest purchases were made in December when the average worked out at £1 18s. 3½d. per person.

TABLE III.

Per Person Expenditure on Foodstuffs.

	Unemployed.		*Employed.*		*Total.*	
	Average Monthly Expenditure.	*Per cent.*	*Average Monthly Expenditure.*	*Per cent.*	*Average Monthly Expenditure.*	*Per cent.*
	£ s. d.		£ s. d.		£ s. d.	
1936.						
July-September	0 16 6	45.0	1 12 0¾	40.5	1 4 0½	42.0
October-December	0 15 6½	43.3	1 15 1⅛	37.1	1 5 0½	38.9
July-December	0 16 0½	44.2	1 13 7½	38.6	1 4 5¼	40.3
1937.						
January-March	0 17 2½	45.8	1 15 9¾	39.0	1 6 2¾	41.1
April-June	0 17 10½	48.2	1 17 6¾	35.7	1 6 9¼	39.4
January-June	0 17 6½	47.0	1 16 7½	37.4	1 6 6	40.3
Year	0 16 9½	45.6	1 15 0¾	38.0	1 5 6	40.3

With the unemployed group spending an average of 16s. 9½d. per head per month on food, and the employed group spending about 35s. 1d., it might be expected that distribution of total food expenditures would show considerable variations. The striking fact is that the employed group show higher expenditures

on every class of food, but the most important differences are as follows :—

Expenditures per Head on Certain Food Groups.

	Unemployed		*Employed.*	
	s. d.	*% Total Food*	*s. d.*	*% Total Food.*
Meat, Fish, Eggs, Cheese ...	3 9	22.4	11 8	33.2
Cereals	3 5	20.2	5 0	14.2
Fats :—				
Butter, Margarine, Suet and Lard	3 7	21.5	5 1	14.5
Milk	1 7	9.3	3 5	9.8
Fruit	0 10	5.1	2 7	7.1
Vegetables	1 5	8.4	2 10	8.1

The low amounts and proportions of expenditures by the unemployed group on the meats and fats groups are very striking, and show where these families seek to make their largest economies. In the cereals group, the proportion is high, but the amount is lower for the employed group, which is evidence of expenditure on the cheaper cereal foods—bread and flour and cheap breakfast food as against cakes, pastries and expensive breakfast foods. In the case of the milk, fruit, and vegetables groups, the amounts are lower but the proportions are fixed almost exactly in proportions in which these families are deprived of spending power; that is expenditures are reduced almost exactly in proportion to resources.

The comparisons are shown in detail below.

TABLE IV.

Average Monthly Expenditure per head on Foodstuffs (12 months)

	Unemployed			*Employed*			*Average*		
	s.	*d.*	*Per cent.*	*s.*	*d.*	*Per cent.*	*s.*	*d.*	*Per cent.*
Meat, Poultry and Game ...	2	7¼	15.6	7	3	20.7	4	9¼	18.9
Fish	0	6¼	3.2	1	6½	4.4	1	0¼	1.0
Cereals and Breakfast Foods ..	3	1¼	20.2	1	11½	11.2	4	1¾	16.3
Suet, Lard and Dripping ..	0	1¼	2.1	0	5¼	1.2	0	4¼	1.5
Butter and Margarine ..	3	3	19.4	4	8	13.3	3	11	15.3
Eggs	0	3¾	1.9	2	2¼	6.3	1	2¾	1.8
Cheese	0	3½	1.7	0	7½	1.8	0	5½	1.8
Milk	1	6¾	9.3	3	5¼	9.8	2	5½	9.6
Beverages	1	0½	6.2	1	9½	5.1	1	4¾	5.5
Preserves	1	1	6.4	2	2½	6.3	1	7½	6.4
Rice, Sago and Tapioca ..	0	1	0.5	0	2¼	0.6	0	1¾	0.6
Fresh Fruit	0	7½	3.7	2	1	5.9	1	3¾	5.1
Other Fruit	0	2¾	1.4	0	6¼	1.5	0	4½	1.5
Fresh Vegetables	1	3¾	7.8	2	7½	7.5	1	11¼	7.6
Other Vegetables	0	1¼	0.6	0	2¼	0.6	0	1¾	0.6
Meals from Home	—		—	0	3½	0.8	0	1½	0.5
Total	16	9½	100.0	35	0¾	100.0	25	6	100.0

Changes towards higher expenditure during the second half of the year were due partly to increases in prices and partly to changes in quantities. Between July, 1936, and June, 1937, which is the period with which we are concerned, the index number of retail food prices rose by 7 points.

Space does not permit the expenditures on the different kinds of foods to be set out for the quarterly peroids. The data relating to total food expenditure for the different quarters given in Table III will therefore have to suffice. It will, however, be useful to make a careful comparison between the average expenditures on the different kinds of foods of these two sets of households, as much may be gleaned from them of the voluntary and compulsory reactions which households in different economic circumstances make in face of changing conditions.

In the following Table the actual increases or decreases in expenditures on the different kinds of foods by the two types of households during the second over the first six months are set out.

TABLE V.

Increases and Decreases in Expenditures on Foodstuffs from previous six months.

	January-June, 1937, over July-December, 1936.		
	Unemployed.	*Employed.*	*Total.*
	s. d.	*s. d.*	*s. d.*
Meat, Poultry and Game ..	— 0 2¼	+ 1 0	+ 0 4
Fish	+ 0 3¼	+ 0 2¼	+ 0 2½
Cereals and Breakfast Foods ..	+ 0 5¼	+ 0 7¾	+ 0 6¼
Suet, Lard, Dripping	—	— 0 0¼	— 0 0¼
Butter and Margarine	— 0 1¼	+ 0 2½	+ 0 0½
Eggs	— 0 1	+ 0 4¼	+ 0 1¼
Cheese	+ 0 0½	+ 0 1	+ 0 0¾
Milk	+ 0 4¼	+ 0 2½	+ 0 3
Beverages	—	+ 0 2¼	+ 0 1½
Preserves	— 0 1¼	+ 0 2¼	—
Rice, Sago and Tapioca ...	+ 0 1¼	— 0 0½	+ 0 0½
Fruit	+ 0 2¼	+ 0 3¼	+ 0 2¾
Vegetables	+ 0 7	— 0 3¼	+ 0 2¼
Meals from Home	—	— 0 0¼	— 0 0¼
All Food	+ 1 6	+ 3 0¼	+ 2 0¾

It is seen from the Table that the total outlay on food increased in both the unemployed and employed groups, the percentage increases being 9.4 and 8.9 respectively, while for the eight households the increase was 8.5 per cent. Differences in monthly expenditures on food per head may be due to many

causes—to seasonal changes in prices as in the case of eggs, or milk, to social habits as in the case of meat in December, and to some extent to seasonal habits of consumption. Periods of maximum expenditure for each of the main food groups are indicated by the Tables.

TABLE VI.

Season of Maximum Food Expenditure (Eight Households).

	s. d.	%	*Month.*
Meat, Poultry and Game ...	5 11¾	22.1	December.
Fish	1 3½	4.7	March.
Cereals and Breakfast Foods ...	4 10½	17.7	March.
Suet, Lard, Dripping	0 5½	1.7	April.
Butter and Margarine	4 2	15.4	December.
Eggs	1 6¼	5.6	December.
Cheese	0 6¼	2.0	February.
Milk	2 9	9.9	March.
Beverages	1 7¼	6.7	November.
Preserves	1 10½	6.9	June.
Rice, Sago and Tapioca ...	0 3	0.9	May.
Fruit	1 9	7.3	August.
Vegetables	2 1	7.5	March.
Meals from Home	0 5	1.5	March.
All Food	27 8¼	—	March.

Having discussed expenditure on foodstuffs in some detail we are now in a position to consider the non-food expenditure. A summary of the general situation is given in Table VII. Among the unemployed households non-food goods accounted for just over half of total expenditure, and for 62 per cent. in the

TABLE VII.

Total Non-Food Expenditure.

	Unemployed		*Employed*		*Total.*	
	Total Expenditure	*% of total.*	*Total Expenditure*	*% of total.*	*Total Expenditure*	*% of total.*
1936	£ s. d.		£ s. d.		£ s. d.	
July-September ...	51 9 3	55.0	113 1 1	59.5	164 10 4	58.0
October-December	51 19 0½	56.7	143 3 0	62.9	195 2 0½	61.1
July-December ...	103 8 3½	55.8	256 4 1	61.4	359 12 4½	59.7
1937						
January-March ...	51 19 0½	54.2	134 5 9½	61.0	186 4 10	58.9
April-June ...	49 0 8½	51.8	142 3 11½	64.8	191 4 8	60.6
January-June ...	100 19 9	53.0	276 9 9	62.6	377 9 6	59.7
Year ...	204 8 0½	54.4	582 13 10	62.0	737 1 10½	59.7

case of the employed group. The employed group increased non-food expenditure by 7.9 per cent. during the period January to June.

A clear indication of the differences in the standards of material comfort enjoyed by these two groups is provided by the disparities in the total expenditure on non-food goods. Though the average size of household was somewhat smaller for the employed than for the unemployed group yet the non-food or miscellaneous expenditure was about 2½ times as much during the first half year and 2¾ times as much during the last six months.

In the following Table the itemised non-food expenditure for the two types of households and for the whole group is set out for the full twelve months. The total food expenditure and the total income received during this period is also given.

TABLE VIII.
Total Non-Food Expenditure (12 months)

	Unemployed.				*Employed*				*Total.*			
	£	*s.*	*d.*	%	£	*s.*	*d.*	%	£	*s.*	*d.*	%
Rent and Rates ...	87	17	0	23.4	102	18	4	12.0	190	15	4	15.5
Fuel and Lighting	29	2	1½	7.7	55	8	10	6.4	84	10	11½	6.8
Clothing ...	9	10	11	2.5	127	15	1½	14.9	137	6	0½	11.1
Insurance ...	19	7	0	5.2	36	5	0	4.2	55	12	0	4.5
Personal ...	18	0	6	4.8	78	19	0	9.2	96	19	6	7.9
Soap and Laundry	6	15	5	1.8	11	14	0½	1.4	18	9	5½	1.5
Thrift Clubs ...	14	19	0	4.0	33	11	3	3.9	48	10	3	3.9
Books, Library Subs. ...	3	12	8	1.0	12	12	0	1.5	16	4	8	1.3
Medical and Chemist ...	7	8	11	2.0	15	15	3	1.8	23	4	2	1.9
Other	7	11	6	2.0	57	15	0	6.7	65	9	6	5.3
Total Non-Food ...	204	8	0½	54.4	532	13	10	62.0	737	1	10½	59.7
Total Food ...	171	5	7½	45.6	326	2	6	38.0	497	8	1½	40.3
Grand Total ...	375	13	8	100.0	858	16	4	100.0	1234	10	0	100.0
Total Income ...	378	11	8	--	1012	11	0	--	1391	2	8	—

In the unemployed group rent and rates were by far the most important items and accounted for just under one-quarter of total expenditure. The small differences in the actual half yearly amounts were due to variations in the rates of the households who made this payment. Over the whole year the average of rent and rates for each household worked out at approximately £1 16s. 0d. per month. Next in order of importance was fuel

and lighting which accounted for 7.3 per cent. of total expenditure during the first six months. Direct expenditure on clothing and household equipment amounted to 3.7 per cent. during this same period. But much of these items are obtained through Thrift Clubs; in fact a greater sum was paid into these Clubs during the first six months than was spent directly on clothing and household equipment. Taken together these two items accounted for 8.2 per cent. of total expenditure although it does not seem probable that the £8 5s. 0d. paid into the Clubs during this period was all drawn out at the end of December. It is highly probable, however, that some of the money paid into Thrift Clubs previous to June, 1936, was utilised during the latter part of the year. Of the direct expenditure made on clothing and household equipment during this period 96 per cent. was for the former and 4 per cent. for the latter. Insurance, which in these housholds mainly represents payments against the insecurity of life accounted for 5.4 per cent. of total income, and personal expenditure for 4.8 per cent. Very small amounts were spent on the remaining items.

In the second six months total non-food expenditure was slightly lower. Of the chief items rent and rates naturally showed little change, while that on fuel and lighting was somewhat higher. Greatest reductions were made in expenditure on clothing and in payments into Thrift Clubs.

In the employed group heavier expenditures were made in every category. These households happened to live mainly in the more expensive quarters and therefore paid more in rent and rates. In the first six months expenditure on fuel and lighting was almost twice that of the unemployed households and the outlay on clothing and household equipment about six times as great. Yet the proportionate expenditure on these items by the employed households was lower than in the case of the unemployed group. The differences in expenditures by these two types of households on the other items is also very striking. "Other" expenditure which accounted for 8.0 per cent. of the total in the employed households included such items as household labour, travelling, education and wireless.

In the second six months total miscellaneous expenditure had increased by 7.9 per cent. from £256 4s. 1d. to £276 9s. 9d. That for the unemployed group, however, showed a reduction of 2.4 per cent. The increased expenditure on clothing by the employed group during the second six months was very marked,

But the only item of outlay which showed any marked seasonal variation was fuel and lighting. The costs incurred by two of the families over a period of twelve months are given below.

(i) Household with Head in Employment
Fuel and Lighting.
(Comprising Coal, Oil, Gas, Electricity and Firewood).

	£	s.	d.
July, August, September, 1936 ...	2	17	8
October, November, December, 1936 ...	3	15	9
January, February, March, 1937 ...	3	15	0
April, May, June, 1937	2	8	6
Total for twelve months	£12	16	11

(ii) Household with no wage-earners.
Fuel and Lighting.
(Comprising Coal and Gas).

	£	s.	d.
July, August, September, 1936 ...	1	2	7
October, November, December, 1936 ..	1	19	3
January, February, March, 1937 .	2	4	5
April, May, June, 1937	1	10	3
Total for twelve months	£6	16	6

On the relation between total income and total expenditure the unemployed households overspent slightly during the first six months and had a slight credit balance at the end of the second six months, thus leaving a very small unspent margin at the end of the year. The employed households, on the other hand, did some saving.

Such, then, are the main features of the expenditures of the two types of households over a period of twelve months. It would have been possible to dwell much more on some of the purchasing habits of the households under consideration and to give a more detailed statistical analysis of expenditures by the use of tabular statements covering each separate month. But it was felt that a clearer view would be obtained if emphasis were laid on the most outstanding features.

Conclusions

The two sets of households studied showed marked differences in economic status. Standards of living were very low in the unemployed group and though those of the employed group were much higher and in every way more satisfactory, other available evidence tends to indicate that relatively little

immediate improvement in living standards occurs when households move from unemployment to employment in an industry where wages are so low as to be insufficient to compensate workers for the extra cost entailed. Additional outlay is needed for better and more food, more and better clothing and more heating and lighting and cleaning materials. And these are only some of the extra items the cost of which is not immediately met by increased earnings and when the duration of employment is likely to be short, members of unemployed households who do secure employment frequently are the cause of added suffering to other members of their households. The fact that householders suffer when they are moved from unemployment to employment at little higher remuneration than that obtained from unemployment benefit, or with little prospect of permanence in the employment leading to higher wages, has been particularly apparent throughout the general investigation of living conditions in the Rhondda Valley. Furthermore, for the true effect of employment on standards of living and on markets for food to be properly evaluated it is neccessary to have an employed group which on the average earns enough to support a desirable standard of living over a fairly long period of time. The employed group studied here satisfies these requirements.

The employed group spent a lower ratio of total expenditure on food than the unemployed group. Increases in food prices resulted in relatively great compulsory shifts of demand for the households in the latter group from the more expensive protective foods to the less protective foods. The shifts of demand were compulsory in the sense that price changes forced householders in the unemployed group to make changes in their budgets with a view to satisfying the hunger of members for food in a way that would make expenditure balance with available income. Thus the influence of the consumption habits of this group on food markets has shown marked change in the period under review, and this must result in modification in the nature of demand in farmers' markets if this process is representative of that which occurs in other households of unemployed people faced with similar problems.

Increased expenditure on food occurred in the employed households but this increase could be borne without the same discernible damage as that resulting to those unemployed or with very low incomes. As evidence of this capacity for tolerating the effect of increased prices may be cited the ability of the employed

group to save for future contingencies and to continue to purchase foodstuffs that had become dearer during the currency of the period but which all human beings are entitled to have.

Wants of a non-food character were moderately well satisfied among the employed households but those of the unemployed were of a bare minimum type. Even the basic non-food requirements like housing, clothing, fuel and lighting and household equipment were inadequate to ensure a decent standard of living and short period employment for low wages did very little to modify these conditions in any desirable way. Thus when the economic status of households is subject to change as a result of employment leading to better incomes for the working class there are many desirable ways in which money can be spent as well as on food. And while incomes are so low as to force householders to choose between purchases of things all of which they need, restriction of purchase must occur somewhere, for the evidence obtainable from these budgets shows that unemployed people are no more prone to run into debt over a period of time than other members of society. As many non-food wants are satisfied by payments of a regular contractual character it seems evident that changes in demand for food will be some of the first to be made. And the nature of these is clearly shown here when prices rise. Thus it might be said that unless society can provide by work or social service incomes which are adequate to maintain desirable standards of living, then the resulting disequilibrium in the markets for foodstuffs will have repercussions in the homes of the farming community. For the position is rendered wholly clear in the words of one of the householders co-operating in this work who said—" the garment has to be cut according to the cloth, and any mishandling in the spending of a shilling reacts on the sum to be spent on other commodities, and some item has to be curtailed or denied altogether to make it up."

THE OPERATION OF FAT CATTLE SUBSIDY IN WALES.

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Introduction.

Valuable information relating to the fat cattle industry in various parts of the United Kingdom has become available as a result of the institution of the Cattle Industry (Emergency Provisions) Acts and the Livestock Industry Act, 1937. South Wales and North Wales form separate divisions and thus it is possible to study the statistical data for Wales and its Agricultural Divisions both absolutely and relatively. The making of a study such as this at any time provides a useful measure of the effects of the fat cattle subsidy on the markets for store and fat stock in Wales but it now becomes more necessary on account of the declaration of the long term policy of the Government in relation to livestock and its operation from the beginning of August, 1937. In this study, however, numbers of animals certified in August of that year are included as if they belonged to the period before the provisions of the Livestock Industry Act, 1937, applied to the administration of the subsidy. Thus records for three complete years are used because these cover a convenient period for forming judgments of the position of the beef cattle industry in Wales.

Subsidy Payments.

The total number of animals certified for subsidy in the United Kingdom in the three years 1934-37 amounted to 4,819,528 and the sum paid to producers amounted to £11,409,951.[1] Average subsidy per animal was £2 7s. 4d. The numbers of animals from Wales certified in the same period and therefore included in the total for the United Kingdom were 254,365 which represents about 5.3 per cent. of the total. But the amount of subsidy paid on these animals represents less than 5.3 per cent. of the total paid to United Kingdom producers because the weights of cattle from Wales were lower than those of the United Kingdom as a whole. Thus it might be said that producers of fat cattle of certifiable quality in Wales have had

[1] Journal of the Ministry of Agriculture, October, 1937. page 669.

£570,500, or approximately 5 per cent. of the total subsidy paid to United Kingdom producers.

This rate of subsidy is relatively lower than the cattle population of Wales seems to warrant. Total cattle above one year old in the United Kingdom amounted to an average of 3,156,200 head in the period 1934-36 and those of Wales to 279,027 head. If it is assumed that these average numbers bear a close relationship to numbers of cattle certified in the period 1934-37, and this should be approximately true as there is a lag in the maturing and feeding processes connected with fat cattle which is allowed for in the figures, then on an average producers of fat cattle in Wales would have been justified in drawing from the "Cattle Fund" a sum bearing a close relationship to the ratio of "other cattle" over a year old in Wales compared with the total cattle of the same categories in the United Kingdom. This ratio amounted to about 9 per cent. Thus the fat cattle producers of the Principality succeeded in securing directly about 5 per cent. of the subsidy while producers of cattle in Wales owned about 9 per cent. of the cattle in the United Kingdom of the age classes from which cattle certified for subsidy were drawn. The cattle producers of Wales would have had a better appreciation of the equity of the subsidy system if the financial provisions had been made equally available to rearers and fatteners.

The dependence of cattle raisers in Wales on store markets is tending to become less marked since the inauguration of the subsidy on fat cattle.

From the standpoint of producers of fat cattle in Wales it is important to assess the absolute and relative degree of reliance placed on the markets for fat cattle in the two agricultural divisions, South and North Wales. The average number of animals certified for subsidy per annum in South Wales was 46,797 and in North Wales 37,991. Thus 55 per cent. of the certifiable cattle came from the former area and 45 per cent. from the latter. But it is remarkable that the ratios of fat cattle certified for subsidy in the two divisions agree almost exactly to those of "other cattle" over a year old. For average annual numbers of "other cattle" in these age classes in the period 1934-36 were South Wales 154,300 and North Wales 124,721 or approximately 55 per cent. and 45 per cent. respectively. Therefore the two divisions of Wales have made use of the facilities for certification of fat cattle with equal intensity,

the differences between numbers certified arising solely on account of the higher cattle population of the Southern as compared with the Northern division.

Sales by Live and Dead Weight.

Less than one per cent. of the total animals certified in the period 1934-37 were presented by deadweight and more than 99 per cent. by liveweight. The numbers by years are shown in the statement below.

Year.	*Liveweight.*	*Deadweight.*	*Total.*
1934-35	83,997	383	84,380
1935-36	85,143	1,178	86,321
1936-37	82,922	742	83,664
Total	252,062	2,303	254,365

Thus sales on a dead weight basis increased somewhat in the second subsidy year but declined in the third. None of these animals were sold on a grade-dead-weight basis according to the records. This, however, is not strictly true for cattle from Wales have been sold quite satisfactorily under the grade-dead-weight scheme of the Ministry of Agriculture. But as the records are made up at the grade-dead-weight certifying centres the countries having no centres are recorded as having sold no animals under the scheme.

Relation of Fat Cattle Sales to Total Sales.

The fattening of cattle for sale in a condition suitable for certification and receipt of the fat cattle subsidy has increased in relative importance in Wales during the currency of the subsidy arrangements. The total sales of " other cattle " over a year old estimated by years were 1934-35, 189,000; 1935-36, 180,000,; 1936-37, 175,000. During continuous periods in the same years commencing and ending three months later the numbers of fat cattle certified for subsidy payments by live and dead weight were 1934-35, 84,380; 1935-36, 86,321 and 1936-37, 83,664. Thus in the first year of subsidy approximate ratio of sales of certifiable fat cattle to total sales of cattle over a year old was 44.6 per cent. and about 48 per cent. in the second and third years. This is the measure of the direct interest of cattle rearers in Wales in the market for prime fat cattle ;and shows a degree of reliance on cattle fattening much in excess of that usually associated with cattle husbandry in the Principality.

Grading Results.

It seems clear, therefore, that cattle fattening as compared with the rearing of stores has been becoming relatively more important. But the difficulties which producers have experienced in getting a high proportion of cattle passed as eligible for subsidy is brought out by the ratios of eligibility in the various countries in the United Kingdom. In the first

Proportions of Presented Animals eligible for Subsidy.

Country.	*1934-35.*	*1935-36.*	*1936-37.*
	%	%	%
England	90.6	90.2	90.9
Wales	82.5	86.1	87.7
Scotland	98.2	97.0	97.5
Northern Ireland	84.9	86.5	84.9

two years of the subsidy period, therefore, the ratio of acceptances of fat cattle as eligible was lower in Wales than for any other part of the United Kingdom. By 1936-37, however, the ratios for Wales were higher than those for Northern Ireland but still below those for England and very much below those for Scotland.

All fat cattle passed as eligible for receipt of subsidy by certifying authorities and graders were not in fact certified and the proportions of eligible animals certified by areas in the United Kingdom are shown below. Thus in all years

Ratio of Eligible Animals Certified.

Country.	*1934-35.*	*1935-36.*	*1936-37.*
	%	%	%
England	95.8	96.3	95.9
Wales	91.9	93.1	92.8
Scotland	97.7	96.0	95.0
Northern Ireland	99.0	100.0	100.0

and in all countries covered by the subsidy, numbers of cattle certified were much lower than those eligible and therefore the ratios of certified to presented animals were still further reduced.[2] This and the low ratio of eligibility account for the somewhat surprising position that only three out of every four animals presented for subsidy in Wales were certified in 1934-5,

[2] The differences in the ratios of eligible and certified animals to total animals presented arose from any of the following:—

(*a*) eligible cattle were withdrawn from certification because no sales were made:

(*b*) buyers of eligible cattle arranged with sellers to pay them the equivalent of the subsidy either in prices or as an addition to them and the buyers would themselves present the animals for subsidy at a later date at the same or other markets.

four out of every five in 1935-36 and little more than this in the eleven months of 1936-37 after which date the conditions with regard to subsidy administration were altered in a number of ways. It will be seen therefore that producers of fat cattle of certifiable quality in Wales have been securing better results in the process of grading as familiarity with and understanding of the conditions relating to certification were becoming more widely realised. But apart from Northern Ireland the figures for Wales are still the lowest.

TABLE I.

Grading Results in Wales.

Month.	*1934-35.* % *of Presented Animals.*		*1935-36.* % *of Presented Animals.*		*1936-37.* % *of Presented Animals.*	
	Eligible	*Certified*	*Eligible*	*Certified*	*Eligible*	*Certified*
September	84.1	76.8	83.1	75.4	85.4	71.8
October	81.0	73.1	83.3	77.2	87.6	76.7
November	80.8	71.6	81.2	75.8	87.4	78.8
December	86.5	78.2	87.5	82.1	89.9	81.0
January	79.8	75.3	87.2	83.2	88.2	84.3
February	81.0	76.7	88.1	84.6	89.0	87.0
March	81.9	79.2	87.5	84.2	88.1	85.1
April	82.7	78.9	86.2	83.1	87.0	85.2
May	81.5	76.6	85.9	79.5	87.4	82.7
June	83.9	76.6	87.1	80.1	85.3	79.1
July	83.5	75.7	86.1	79.5	88.0	82.3
August	83.8	72.4	86.8	77.3	88.7	80.2
Year	82.5	75.9	86.1	80.1	87.7	81.1

Slaughter of Steers and Heifers. [3]

For Wales as a whole the number of steers certified was very slightly in excess of the number of heifers, but this general condition was made up of a heavy excess of steers in North Wales and a heavy excess of heifers in South Wales. Of the total steers certified in Wales about 53 per cent. came from the Northern and 47 per cent. from the Southern division, while of the total heifers certified nearly 64 per cent. came from the Southern and 36 per cent. for the Northern division. There are, however, some variations from these positions, more particularly in the case of steers. Supplies of steers in North Wales are relatively heavy from August to November inclusive, and relatively light March

[3] The term heifers as used in this study includes cow-heifers for the latter formed only about 3 per cent. of certifications in Wales.

to June. On the other hand, supplies of steers in South Wales are relatively heavy March to June inclusive and relatively light in the autumn and early winter, except during December when they appear to be prepared for the Christmas markets. In the case of heifers, the very heavy supplies from South Wales dominate the total supplies throughout the year. (Table II.)

TABLE II.

Proportions of Steers and Heifers certified by Areas, 1934-37.

Month.	*Steers.*		*Heifers and Cow Heifers.*	
	North Wales.	*South Wales.*	*North Wales.*	*South Wales.*
	%	%	%	%
September	57.0	43.0	38.4	61.6
October	56.4	43.6	39.0	61.0
November	56.0	44.0	38.8	61.2
December	51.4	48.6	35.7	64.3
January	55.4	44.6	38.0	62.0
February	54.0	46.0	36.7	63.3
March	49.8	50.2	32.4	67.6
April	48.4	51.6	35.8	64.2
May	43.0	57.0	30.8	69.2
June	42.2	57.8	30.1	69.9
July	53.7	46.3	37.1	62.9
August	54.5	45.5	35.8	64.2
Year	52.8	47.2	36.4	63.6
All Wales	50.8		49.2	

Monthly Proportions of Steers and Heifers.

Although the proportions of steers and heifers show a slight excess of steers over heifers taking the whole year together, and the whole Principality as one area, there are important conditions in the tendency to market steers more heavily at some periods and heifers more heavily at other periods. The period of light marketing of steers is from June to November or December inclusive, while this is the period of heavy marketing of heifers. On the other hand, the period of heavy marketing of steers is January to May inclusive while this is the period of light marketing of heifers. The variations in the make-up of the supply according to sex hold good equally in North Wales where total numbers of steers are vastly in excess of numbers of heifers and in South Wales where the reverse position is found. (Table III).

TABLE III.

Divisional Certification of Steers and Heifers by months, 1934-37.

Month.	North Wales.		South Wales.		Total.	
	Steers.	*Heifers and Cow Heifers*	*Steers.*	*Heifers and Cow Heifers*	*Steers.*	*Heifers and Cow Heifers*
	%	%	%	%	%	%
September	56.9	43.1	38.4	61.6	47.2	52.8
October	57.5	42.5	39.9	60.1	48.2	51.8
November	57.4	42.6	40.2	59.8	48.3	51.7
December	59.1	40.9	43.2	56.8	50.1	49.9
January	62.5	37.5	45.1	54.9	53.4	46.6
February	67.3	32.7	50.4	49.6	58.3	41.7
March	68.4	31.6	51.1	48.9	58.5	41.5
April	65.3	34.7	52.8	47.2	58.2	41.8
May	62.3	37.7	49.4	50.6	54.2	45.8
June	52.0	48.0	39.0	61.0	43.6	56.4
July	52.6	47.4	36.1	63.9	43.5	56.5
August	52.6	47.4	34.1	65.9	42.2	57.8
Year	59.9	40.1	43.6	56.4	50.8	49.2

Seasonality of Marketing.

In order to have a clear view of the seasonality of marketing it is necessary to bear in mind these conditions—

(1) The approximate equality of numbers of steers and heifers over the whole year and the whole Principality.

(2) The predominance of supplies of heifers in South Wales and of steers in North Wales.

(3) Tendencies to heavy marketing of steers and light marketing of heifers (and *vice versa*) at various seasons as previously described.

(4) Marked seasonal changes in total supplies of steers and heifers combined.

The last condition has now to be displayed, but in order to give fair measures of seasonal differences in supplies it is necessary to modify the crude figures of monthly deliveries. (Appendix A). The markets where certification occurs are held on different days of the week and while some days are extremely important as regards numbers of markets held others are relatively unimportant in this respect. Generally in Wales, Mondays and Tuesdays are the most important market days for fat cattle. Because months may frequently have a high number of important market days adjustment is necessary in order to make numbers coincide more closely with what actually occurs in the marketing process. Here an attempt has been made to do this and while the yearly totals remain the same there is re-distribution of numbers between the months.

Steers. In 1934-35 the seasonal pattern of certification of steers differed somewhat in the two agricultural divisions. Monthly numbers expressed as a percentage of yearly numbers for North Wales rose to a peak in January (13.8 per cent.), declined to June (4.0 per cent.) and then rose again in July and August. More than three and a half times as many steers were certified in January as there were in June. The pattern of seasonal movements in certification for South Wales showed a tendency to rise from September to February and then to decline quite regularly to the end of the subsidy year. Maximum monthly supplies occurred in February (12 per cent.) and minimum in August (4.7 per cent.). The range between highest and lowest, therefore, was much narrower than that for the Northern area.

Taking the position of steers for Wales as a whole the trend of monthly supplies rose to January (12.6 per cent.) and declined to July (4.4 per cent.) and rose somewhat in the following month. Thus the seasonal pattern of supplies of steers is something of a compromise between that of the Northern and Southern area.

Considerable change occurred in the seasonal character of certification in 1935-36. In North Wales the bulk of supplies were marketed in the period September to February (12.1 per cent.) and in fact the latter month shows the highest monthly supplies. There was a distinct decline in numbers after this month up to June (3.0 per cent.) when only one quarter of the February number of steers was certified.

There was less concentration of marketing in the period September to March in South Wales by comparison with North Wales. Greatest monthly supplies occurred in March (11.1 per cent.) and the minimum in May and June (5.5 per cent.). Thus the range of variation in monthly supplies was much less in the Southern area than in the Northern area. Again the seasonal pattern of monthly supplies for Wales conforms closely to that of the two areas, supplies reaching a maximum in February (11.6 per cent.) and a minimum in June (4.1 per cent.).

A somewhat more irregular pattern is shown by the seasonal supplies of fat steers in North Wales in 1936-37. Maximum supplies occurred in November (13.7 per cent.) and minimum in June (2.7 per cent.). Thus more than five times the number of steers were marketed in the former month than in the latter which shows that there was a tendency for the seasonality of marketing to become wider and more irregular between the

months of heavy and light supplies as compared with previous years. Broadly the greatest concentration of monthly marketing of steers showed little change in South Wales, supplies rising from September (8.6 per cent.) to December and January (11.4 per cent.) then falling to the minimum level in June (4.5 per cent.) and then tending to rise again except in August. The range of variation in monthly supplies, though much narrower in this area than in the Northern one, was therefore wider than that of the previous year. Thus the position in Wales in 1936-37 was one showing some change in the seasonal pattern of supplies as compared with former years. Maximum supplies occurred in November (12.8 per cent.) and minimum supplies in June (3.5 per cent.).

Taking the figures for the three years, a greater degree of stability is introduced for the extreme fluctuations of a single year are masked. For the Northern area the bulk of supplies went forward in the period September to February, those for the remaining months being distinctly lower. Minimum monthly supplies occurred in June (3.2 per cent.) and the maximum in January (12.5 per cent.). So there were nearly four times as many steers marketed in the area in January as there were in June in the three years.

The period of heavy marketing in South Wales tended to begin a month later and end a month later than that in North Wales. The months of heaviest supplies were December and February (11.4 per cent.) and that of the lightest monthly supplies June (5.0 per cent.). So the range of variation in monthly supplies was much narrower than that for North Wales.

In Wales as a whole the bulk of supplies of steers in the three years occurred in the period October to March; those in the remaining months being generally much lower. The maximum monthly supplies occurred in January (11.9 per cent.) and the minimum in June (4.1 per cent.). Thus the characteristic feature of all supplies of steers for certification is the wide range of variation in monthly supplies arising chiefly as a result of the marked seasonality of supplies in North Wales.

Heifers. The seasonal pattern of supplies of heifers shows remarkably little variation from that of steers. The bulk of supplies in 1934-35 occurred in the months of October to February in North and South Wales. Maximum supplies in both occurred in November (12.4 per cent. and 11.9 per cent.) and the minimum in May (3.4 per cent. and 5 per cent.). Again the Northern area shows the greater monthly variations in supplies,

It might be said that in this year the beginnings of increases in monthly supplies of heifers occurred two or three months earlier than those of steers and reached a peak earlier and declined earlier. The same general features characterised supplies for Wales. The range of variation being 12.6 per cent. in November to 4.4 per cent. in May. Some change in pattern occurred in 1935-36. Again the bulk of supplies occurred in the period September to January but the monthly ratios for North Wales were irregular even in this period. The trend in the other months was unchanged. Maximum monthly supplies in North Wales were in October (13.1 per cent.) and maximum in May (3.9 per cent.) Thus a wide degree of variation was still shown by supplies in the Northern area. Maximum monthly supplies for South Wales were in November and December (11.2 per cent.) and the minimum in April (4.5 per cent.) showing a degree of variation of monthly supplies much below that for North Wales.

Supplies of heifers in the whole of Wales reached their highest monthly level in October (11.7 per cent.) and then declined to May (4.3 per cent.) after which month they increased gradually to the end of the subsidy year.

The seasonal pattern of supplies of heifers remained substantially unchanged in 1936-37 for both agricultural divisions with the exception that maximum monthly supplies occurred in November (14.5 per cent.) in the North and October in the South (11.9 per cent.). Minimum monthly supplies were in May in both areas being 3.3 per cent. in the North and 4.1. per cent. in the South.

Thus the average position for Wales in the three years was that supplies rose to a maximum in November (11.6 per cent.) and declined to a minimum in May (4.5 per cent.) and rose from this to the end of the subsidy year.

Total Supplies

The combined seasonal pattern of supplies of steers, heifers and cow-heifers for 1934-37 shows that the important periods for selling lasted from September to about March. Maximum monthly supplies occurred in the North in November (12.1 per cent.) and in the South in December (11.4 per cent.) and minimum monthly supplies in both areas occurred in May or June being 3.7 per cent. and 5.1 per cent. respectively. Thus the range of monthly variation in supplies continued to be much greater in the North than it was in the South. The position for

the whole of Wales showed much the same general features and was in effect an average of those for its respective agricultural divisions.

Supplies and Prices.

One of the main problems facing producers of fat cattle in Wales is to even out these extreme variations in supply in order to market more cattle when prices are favourable. Average prices obtained per cwt. for certified fat cattle in Wales are not obtainable but if it can be assumed that they would follow the same seasonal trend as those of England and Wales then the average relation of monthly supplies and prices would be of the character illustrated below.

Relation between Monthly Supplies and Prices, 1934-37.

	% Monthly Supplies of all certified Cattle in Wales. (by liveweight).	*Average price per live cwt. England and Wales. Shillings.*
September	9.1	35.8
October	11.2	33.9
November	11.5	33.2
December	11.2	35.0
January	11.3	35.4
February	10.2	35.1
March	8.3	35.4
April	5.8	36.6
May	4.5	38.6
June	4.7	40.1
July	5.7	39.3
August	6.7	37.6

It is quite clear therefore that maximum supplies by months and by periods coincide with minimum prices. The effect of these is to some extent masked because the market was improving during the greatest part of the period. So far as it is technically possible a greater concentration of supplies in the high price months should be profitable.

Conclusions.

Producers of fat cattle in Wales have drawn about 5 per cent. of the sums paid out of the "Cattle Fund" to beef producers in the United Kingdom in the period 1934-37 while Wales reared about 9 per cent. of the cattle from which sales of fat cattle were made. This condition arises on account of the special nature of sales of cattle in Wales. Formerly most of the cattle in the Principality intended for feeding were sold in store condition and a reputation for the rearing of good store

cattle had been built up. More reliance is now placed on the fat cattle market by cattle producers probably as a direct result of the subsidy available on such sales and of the relatively unfavourable prices of stores in 1934, 1935 and even later. Of the estimated total sales of cattle, store and fat, around 48 per cent. were certified for subsidy in the years 1935-37.

The proportions of presented animals eligible for certification are a fair measure of the knowledge of market conditions for prime fat cattle possessed by feeders. And the grading results show that until recently other countries in the United Kingdom showed much better results than those of Wales. Some improvement has occurred and the Welsh figures are now better than those of Northern Ireland, but poorer than those of England and Scotland. This shows that some producers of fat cattle in Wales were operating in an enterprise with the market conditions of which they were somewhat unfamiliar. Indeed it would be surprising if anything but this tendency were shown in periods when prices of store cattle were unfavourable.

While no suggestion would be made that farmers in Wales who have more or less specialised in fattening cattle are less efficient or have less knowledge of their business than specialist fatteners of English areas, it is probably true that a larger proportion of Welsh cattle presented for certification will normally come from somewhat irregular fatteners, those who sometimes fatten and sometimes sell stores, or sometimes "carry forward" and sometimes fatten the older cattle, than is the case in other areas. Also, it must be remembered that a large number of fatteners of cattle, whether regularly or intermittently following this business, have been used to preparing cattle for the markets of South Wales and the North West of England which do not make demands for large numbers of thoroughly finished stock, but have always taken large proportions of animals in relatively lean condition.

Remarkable similarity has been shown by the two agricultural divisions as regards the relative numbers of cattle certified. South Wales with 55 per cent. of cattle stocks has had 55 per cent. of total certifications for Wales and the ratios for North Wales are therefore 45 per cent. Apart from the absolute variation in numbers of cattle certified in the two areas the outstanding difference in the character of certifications on a live weight basis has been the tendency of North Wales to sell much the greater proportion of steers and South Wales that of heifers

certified. This difference in the structure of the feeding enterprise in the two areas is important and is related to the nature of cattle husbandry in the respective areas.

The dependence of the South Wales division on dairy farming has led to heavy slaughter of bull calves at young ages and heifers are reared and purchased for drafting into herds or selling in the market. But many of the heifers so reared prove unsuitable for dairying and when they are inclined to be " beefy " they tend to make good prices in the market for fat cattle. For the market for stores for fattening usually shows little demand for these as they are reared and sold in areas which have suffered some loss in reputation for production of good quality stores for feeding and buyers for the latter purpose avoid markets in these areas except as a last resort. Last autumn and spring, however, these districts attracted more buyers on account of relative shortage of stores thus it would not be surprising if the numbers of heifers and for that matter numbers of all fat cattle certified in Wales declined as a result of the favourable prices obtaining in the store cattle markets and the possibility of avoiding the risks of the fat cattle market.

The North Wales division has been less interested in milk production and in many districts has retained good types of dual purpose herds—the steers from which make good beef cattle and the heifers from which go to dairy herds. There has been a good deal of retention of heifers to sell as first-calvers to the milking areas east and north-east of North Wales and this would reduce the proportion of heifers in the total supply. On the other hand, in the districts in which Welsh Blacks are reared producers rear and sell all steers while retaining some heifers.

Wales as a whole does not seem to be slaughtering heifers at an abnormally high rate or at a rate tending to cause depletion in the cattle stocks considered from a numerical standpoint. Of the numbers of prime cattle which producers in the Principality must sell each year, less than a quarter are slaughtered as fat heifers. This must mean that a full complement of heifers is available in the cattle that remain to be sold in other ways and the number of heifers in calf on June 4th, 1937, were higher than in the previous year thus showing that little restriction in numbers of heifers for other uses arises despite the increase in in the numbers and ratios of heifers certified. Distinct trends are shown in the ratios of steers and heifers certified by months and the trends of these are broadly similar in both divisions of Wales.

More than the yearly average of heifers are marketed in the months June to December and less than this in the period January to May. The position with regard to steers is the reverse of this. The periods when the ratios of steers become very low and those of heifers very high is June to August while the ratios for heifers are very low in the period February to April and those for steers very high.

These facts indicate that heifers are favoured for grass feeding while steers are favoured for stall feeding.

The most important features of the data with regard to rate of marketing are the extreme variations in the numbers of animals certified in the months of low supply and those of high supply and the remarkable concentration of supplies in the months of low seasonal prices for fat cattle. It is hard to believe that these extreme fluctuations are inevitable. For the variations in monthly supplies are very much wider in North Wales than they are in South Wales for the classes steers and heifers. And agricultural conditions in the two divisions are such that what is possible as regards regularising the rate of marketing in one should be possible in the other thus improving receipts without causing substantial increase in costs.

The most important features of the study to producers of fat cattle in Wales are : that more improvement in quality of products is still necessary in addition to that which has already occurred and despite the serious natural and market handicaps with which feeders on all but the best farm lands of the Principality have to contend; that immediate and serious attention be given to the problem of providing more even supplies in Wales and Monmouthshire especially in North Wales; and that the numbers of animals sold by dead weight and dead-weight-grade seem to be unwarrantably low.

APPENDIX.

Numbers of Animals certified by Divisions, Classes and Months, 1934-37.

Steers.

Month.	*North Wales.*		*South Wales.*		*Total.*	
	Number	*% by month*	*Number*	*% by month*	*Number*	*% by month*
September	6,183	9.1	4,673	7.7	10,856	8.5
October	7,683	11.4	5,932	9.8	13,615	10.6
November	7,835	11.6	6,164	10.2	13,999	10.9
December	7,247	10.7	6,853	11.4	14,100	11.0
January	8,415	12.5	6,773	11.2	15,188	11.9
February	8,111	12.0	6,905	11.4	15,016	11.7
March	6,105	9.0	6,159	10.2	12,264	9.6
April	4,131	6.1	4,404	7.3	8,535	6.7
May	2,634	3.9	3,488	5.8	6,122	4.8
June	2,193	3.2	3,007	5.0	5,200	4.1
July	3,363	5.0	2,896	4.8	6,259	4.9
August	3,730	5.5	3,111	5.2	6,841	5.3
Total	67,630	100.0	60,365	100.0	127,995	100.0

Heifers and Cow-Heifers.

Month.	*North Wales.*		*South Wales.*		*Total.*	
	Number	*% by month*	*Number*	*% by month*	*Number*	*% by month*
September	4,673	10.4	7,488	9.5	12,161	9.8
October	5,711	12.6	8,922	11.3	14,633	11.8
November	5,808	12.9	9,174	11.6	14,982	12.1
December	5,008	11.1	9,017	11.5	14,025	11.3
January	5,043	11.2	8,235	10.4	13,278	10.7
February	3,941	8.7	6,805	8.6	10,746	8.7
March	2,824	6.2	5,888	7.5	8,712	7.0
April	2,188	4.8	3,936	5.0	6,124	4.9
May	1,592	3.5	3,574	4.5	5,166	4.2
June	2,018	4.5	4,696	6.0	6,714	5.4
July	3,021	6.7	5,122	6.5	8,143	6.6
August	3,362	7.4	6,021	7.6	9,383	7.5
Total	45,189	100.0	78,878	100.0	124,067	100.0

Total Animals.

Month.	*North Wales.*		*South Wales.*		*Total.*	
	Number	*% by month*	*Number*	*% by month*	*Number*	*% by month*
September	10,856	9.6	12,161	8.7	23,017	9.1
October	13,394	11.9	14,854	10.7	28,248	11.2
November	13,643	12.1	15,338	11.0	28,981	11.5
December	12,255	10.9	15,870	11.4	28,125	11.2
January	13,458	11.9	15,008	10.8	28,466	11.3
February	12,052	10.7	13,710	9.8	25,762	10.2
March	8,929	7.9	12,047	8.7	20,976	8.3
April	6,319	5.6	8,340	6.0	14,659	5.8
May	4,226	3.7	7,062	5.1	11,288	4.5
June	4,211	3.7	7,703	5.5	11,914	4.7
July	6,384	5.7	8,018	5.8	14,402	5.7
August	7,092	6.3	9,132	6.5	16,224	6.5
Total	112,819	100.0	139,243	100.0	252,062	100.0

THE DEVELOPMENT OF A HORSE MARKET IN WEST WALES.

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Introduction.

The horse population of Wales and Monmouthshire has declined continuously since 1921. Between 1918 and 1921 numbers fell to 1920 and then touched a high figure which has never been approached since. Numbers in 1937 were fewer than those for 1921 by these numbers:—Horses for agriculture, 22,406; stallions, 220 (1936); horses one year old and over, 20,098; horses under one year, 6,617; other horses, 12,665; total horses, 68,140. The most consistent and regular decline in numbers occurred in the class "horses used for agriculture." Numbers of stallions were falling until 1931 but since then appear to have doubled. Numbers in the classes "horses over a year old," "horses under a year old" and "other horses" have shown a tendency to increase since 1935, or at least that the downward movement has been arrested.

Llanybyther Horse Sales.

The special horse sales at Llanybyther began in January, 1918, when prices were very high and the country was being scoured for supplies. They increased in importance while horses were being returned from France and other fields of war, and again since that time despite the falling trend in total numbers of horses kept on farms in Wales and Monmouthshire since 1921. The records for the first two years are incomplete and therefore the total numbers of sales held in the years 1918 and 1919 are not known with certainty. The records of sales for 1920 however are complete and six sales were held during the year in the months of February, April, May, June, August and November and 243 horses were sold, 87 of them light and 156 heavy horses. The sale had grown considerably by 1924 when eleven sales were held, one in each month of the year except December and 475 horses were sold, 145 of the light and 330 of the heavy classes. Further expansion in sales occurred in 1926; eleven sales again being held, December being the only month without one. More horses were sold (591), the numbers of light horses increasing (276) and those of heavy horses diminishing (315) by comparison with 1924.

Steady progress was made in the remaining years of that and the commencement of the following decade. In 1934 eleven sales were held, one in each month except December and 260 light and 514 heavy horses, making a total of 774, were sold. Increase in numbers of horses sold occurred in 1935 when buyers were secured for 335 light and 582 heavy horses, making a total of 917. Further expansion occurred in 1936 when a total of over 1,000 were sold in eleven sales, 351 of the light and 680 of the heavy classes. Thus the records show continuous increase in business during a period when numbers of horses on farms were falling.

Sales, Withdrawals and "dead" Entries.

Increases in the numbers of horses sold is only one form of the development shown by this sale. The actual number of entries is always much in excess of sales. For some horses entered fail to appear and some are withdrawn at the prices offered in the sale ring They may be sold later either through the auctioneers' books or privately but the extent to which private selling is done is not accurately known. Thus actual sales by auction through the ring is the only reliable guide to the numbers of horses sold.

The improvement in the position with regard to numbers of horses sold in relation to total entries has been almost continuous since the commencement of the market but the difference in the lowest (32 per cent.) and the highest proportions (44 per cent.) sold is only 12 per cent. and it is thus clear that great care is necessary in the organisation and conduct of sales for the margin between the most successful and the least successful years as regards ratio of total entries sold by auction is quite narrow.

The proportion of horses put through the sale ring and remaining unsold fell sharply to 1926 but in the remaining years some tendency to increase was exhibited. And this small increase can become really serious to owners and users of the market if it cannot be quickly arrested, for the charges for selling cannot stand the strain of heavy withdrawals for a long period without endangering the continuance of the market or lowering the quality of the sales services offered. Failure to sell horses offered when fair bids according to prevailing prices are made discourages intending buyers and is a cause of weakness. This is not to say that the withdrawal of horses from the sale ring is wrong in all circumstances. But it is wrong when prices offered are reasonable and when subsequent private sales are made at prices at or

below those genuinely offered in the sale ring. Thus the problem of unsold animals becomes one of the most serious which the market owners have to face. Much the same observations apply to entries that do not appear at the sale at all. On the whole this difficulty is much less serious from the point of view of immediate costs, and the tendency to make entries which fail to appear in the market shows some relative decline. Still the proportion of entries which are not implemented is high and the printed catalogue cannot be an accurate guide to buyers as to numbers, classes or types of horses offered. All that buyers who have experience of the mart will know is that the total numbers offered are certain to be lower than those shown on the catalogues.

TABLE I.

Proportion of Horses Entered sold through the ring.

Particulars	*1920* *No.*	*1920* %	*1924* *No.*	*1924* %	*1926* *No.*	*1926* %	*1934* *No.*	*1934* %	*1935* *No.*	*1935* %	*1936* *No.*	*1936*
Sales ...	243	35	475	32	591	38	774	42	917	44	1,031	42
Unsold ...	350	51	658	45	335	22	441	24	540	26	640	26
Non-Arrivals	98	14	337	23	622	40	636	34	627	30	779	32
Total entries	691	100	1 470	100	1,548	100	1,851	100	2,084	100	2,450	100

There is no regular seasonal variation in the proportions of non-arrivals or withdrawals. But as the years have passed there appears to have been an improvement in the proportion of sales to total entries, and in particular a reduction of withdrawals and in a higher proportion of cases the highest bid has been accepted.

Variations in Sales and Withdrawals.

		Per cent. of Total Entries.		
Period 1920-24-26		*Average*	*High.*	*Low.*
Sales	...	35	50	26
Non-arrivals	...	21	30	11
Withdrawals	...	44	51	24
Period 1934-36.				
Sales	...	43	51	32
Non-arrivals	...	32	35	29
Withdrawals	...	25	33	15
Year 1936.				
Sales	...	42	54	35
Non-arrivals	...	32	40	21
Withdrawals	...	26	32	12

It is difficult to account for the failures to deliver animals voluntarily entered for sale which have varied anywhere between

10 and 40 per cent. of total entries. There is some solicitation, for that is necessary when a sale is to be organised and advertised, but there is no undue amount and no pressure whatever. But the number of "dead" entries makes considerable difficulty in organising the market, especially when it exceeds 20 per cent. of the entries. Buyers of horses travel long distances to supply centres, and on the whole much longer distances than is usual for buyers of other types of stock. In the past buyers have been used to a good deal of travel "looking for horses," particularly the "colliery" types, but they have not recently been so eager to travel and would very much prefer having animals gathered together for inspection and sale as is the case in this mart. Yet farmers who have horses to sell sometimes hold them in the expectation of a caller or hearing of a possible buyer at the local general markets, then enter them for sale in this mart, fail to deliver them, and then hold them on the farm again. The kernel of the difficulty seems to be that farmers have no fixed period at which they intend or expect to sell a horse, even one bred and reared primarily for sale.

In the case of store lambs the period of sale will not usually vary more than a month or two from farm to farm, or from year to year, in a given district. Store cattle will be sold in spring or autumn and the usual variation in period of sale is not more than six months. And stock of these types are always sold: "the horse is the friend of man" and may never be sold though he may be more or less on offer for a long period and may be definitely entered for sale by auction more than once.

In the case of entries delivered to the mart withdrawn because the reserve is not reached, or by a bid on behalf of the seller, the considerations are somewhat different. In the case of "prime" horses there will usually have been some definite preparation for sale, and there is a definite testing of the market. Yet in the case of other types of stock farmers would not withdraw such proportions as 20, 30, 40 per cent. whatever the bids so long as they are in line with "times prices" or prices current. In the case of horses there are many offers for sale which are not accompanied by recognised need to sell, but rather of the character—"I will sell if I am tempted by the price." In this connection it must be noted that in the period under review the horse market has suffered an unusual combination of market conditions—reduced supplies and falling prices; and until 1934 or 1935 the falling supplies were equal to diminishing demands.

But the supply of working horses on farms was also falling to some extent, and in the later part of the period farmers began to realise needs of keeping back some of the horses, which might otherwise have been sold, to maintain the equine equipment of the farms. Nevertheless, when all the rational economic or business bases of sellers' actions have been considered there remain elements of casualness, of tempting fortune, of putting sentiment before business, in the withdrawals of horses offered.

Organisation of the Market.

Sales have usually been held once every month, with the exception of December, in every year for the last 15 years or so. Entries of horses for sale are received by postal and personal communication and the particulars required are provided by vendors. Certain of these particulars, such as the statements regarding soundness and willingness to work, ride and drive, form the basis of the contract between buyers and sellers. The livestock salesmen put the entries into appropriate classes and types and publish and sell a catalogue of entries. Names of sellers may appear in the list but not addresses. This omission is intentional so that the printed catalogue is little guide to horse dealers wishing to buy horses entered for the sale between the time of printing the catalogue and the day of the sale. Space is sometimes, but not always, left for late entries. Horses entered which put in an appearance at the sale are expected to arrive on the sale premises at about 10.30 a.m. An inspection of them is possible in commodious stables where supplies of feed and water are available. Selling commences about 11.30 to 12 noon and since the market has increased in size two rings operate at the same time. Some difficulty is experienced in conducting selling in this way for descriptions of horses by vendors are not accurate enough in all cases to make proper and effective classing of types. Thus by inadvertence horses of similar type may be sold in both rings at the same time. This tends to split the buyers of horses of similar type into two groups, which is very undesirable. After sales are made representatives of the livestock salesmen undertake the loading of stock for transporting if buyers ask for this to be done. Moreover they act as voluntary arbitrators between buyers and sellers in cases of disputes. The number of returns of horses to vendors on account of failure to satisfy the descriptions and guarantees made of them are extremely low. According to the sale sheets less than

a dozen horses were " returns " in the three years 1920, 1924 and 1926. In the three years 1934-36, despite the big increase in sales, only just over a dozen were returned. Returns therefore averaged about 4 per year and the amount of work required in relation to disputes has been low and effective.

All horses entering the sale yard bear an entrance fee in proportion to the reserve price. Where this is under £20 the charge is 2s. 0d.; £20 and under 40, 3s. 0d.; £40 and over, 4s. 0d. This fee is not returned to owners of horses which have passed through the market and remain unsold but is returned to those owners whose horses have been sold and a charge of 6d. in the £ is made for selling. Private treaty sales on the market premises are forbidden and when discovered bear both the selling and entry fee charges.

Types of Horses sold.

Practically a third or more of the horses sold have been of the light class and around two-thirds of the heavy class. Fillies foals and colts and ponies in the light class were sold in greatest

TABLE II.

Numbers and Types of Horses sold.

Type of Horses.	*1920*	*1924*	*1926*	*1934*	*1935*	*1936*
Light Horses:						
Cobs	7	97	186	155	218	199
Ponies	29	26	48	88	30	32
Vanners	6	13	32	52	75	108
Fillies, Foals and Colts ...	45	7	1	6	8	11
Mares and Foals ..	—	—	—	—	—	1
Others	—	2	9	9	9	—
Total	87	145	276	260	335	351
Heavy Horses:						
Cart	121	265	178	312	303	411
Colliers	15	35	120	140	202	186
Fillies, Foals and Colts ...	12	21	7	17	52	71
Mares and Foals ...	4	1	—	1	2	—
Others	4	5	10	14	28	9
Total	156	330	315	514	582	680
Grand Total ..	243	475	591	774	917	1,031

numbers in 1920 but from 1924 onwards more cobs were sold than any other kind. Combined sales of cobs and vanners represented the bulk of the sales after 1920. Only small increase occurred in sales of ponies by comparison with those of cobs and vanners.

Supplies of cart horses have been the foundation of sales since the commencement of the market. Sales of colliery horses have been increasing but in total numbers they are a long way behind those of cart horses. Combined sales of these two classes of heavy horses dominate the character of sales in the heavy horse class, the only other development worthy of note being that of the increase in numbers of fillies, foals and colts sold in the years 1934 to 1936. But this is a small gain by comparison with that for colliery horses.

Seasonality of Sales.

Supplies from local sources dominate the sales both by season and by types of horses. There are two main selling periods, the "spring" and the "autumn." During the most recent period, when sales have been larger, the "spring" period has lasted from February to May and more or less to June. The "autumn" period lasts from September or October to November. In the earlier period, the same seasonal changes in supplies are indicated, but movements are more erratic, probably partly because of the smaller numbers. Heavy horses, vanners, cobs and colliers, appear to swell the seasonal supplies in both these periods. There

TABLE III.

Monthly variation in Sales.

Month.	*1924*		*1926*		*1934*		*1935*		*1936*	
	No.	%	*No.*	%	*No.*	%	*No.*	%	*No.*	%
January ...	21	4.4	50	8.5	55	7.1	50	5.5	72	7.0
February ...	52	11.0	91	15.4	100	12.9	116	12.7	106	10.3
March ...	46	9.7	69	11.7	69	8.9	113	12.3	111	10.7
April ...	33	6.9	74	12.5	98	12.7	146	15.9	168	16.3
May ...	88	18.5	58	9.8	97	12.5	104	11.3	141	13.7
June ...	56	11.8	58	9.8	67	8.7	93	10.1	109	10.6
July ...	13	2.7	39	6.6	21	2.7	34	3.7	25	2.4
August ...	33	7.0	28	4.7	35	4.5	36	3.9	42	4.1
September ...	54	11.4	44	7.4	89	11.5	61	6.7	68	6.6
October ..	28	5.9	34	5.8	77	10.0	89	9.7	123	11.9
November ...	51	10.7	46	7.8	66	8.5	75	8.2	66	6.4
Total ...	475	100.0	591	100.0	774	100.0	917	100.0	1,031	100.0

are tendencies to sell fillies and colts about May, and, of course, suckers and foals in the autumn. There are periods when there is a certain amount of departure from the prevailing trend in the seasonality of selling, such as sudden demands for colliery horses and cobs but when these conditions arise they exercise much more direct influence on sales outside the regular market than they do

inside of it. Sales made privately on farms indirectly affect future supplies on the market but this influence is not large.

Table III shows the position in summary form by months and years from the 1924 sales since which time eleven sales per annum have been held in the years for which records have been available. And this result is the final form of seasonality of sales of horses from all sources and of all classes. Moreover the degree of seasonality of sales shown may be said to be that of local supplies for they dominate supplies at all periods in all years even though a somewhat wider area of supply is shown in the last years.

There are some indications that the larger sales are more satisfactory to sellers for it appears that the proportion of sales to total entries is higher in the months of larger sales—February, March, April and May, and October and November. It may be presumed also that the larger sales are more satisfactory to buyers, because they get a somewhat wider selection of supplies. The bigger sales taken as a whole attract the largest relative numbers of willing buyers and they show better absolute and relative results in numbers and proportions of horses sold than the smaller saler. The smaller sales, especially the smallest of July and August, show high proportion of entries withdrawn.

Sources and Destinations of Supplies.

The market has two functions : it acts as a local exchange especially as regards suckers and foals, colts and fillies, and mares for breeding purposes, but to a small extent as regards other horses; and it acts as a collecting centre and market place where local sellers may display their surplus and prime horses and where they may meet buyers from distant centres. The market does not attract any large number of worked-out town horses for return to farms.

The area supplying the market in 1920 was almost confined to the counties of Cardigan and Carmarthen, only three horses from other areas being sold. The position was practically unchanged by 1924. In that year, with much heavier sales, only three horses from outside of these counties were sold. Much the same situation prevailed in 1926. Out of 591 horses sold only sixteen came from counties outside and these were mainly of the light class. Relatively little change had occurred by 1934 for only thirty-two out of 774 horses came from counties outside those of Cardigan and Carmarthen, these were Glamorgan,

Pembroke and Brecon. The location of supplies widened a little in 1935. Out of 917 total sales fifty-one came from Glamorgan and fourteen from Pembrokeshire, four from Breconshire, two from Montgomeryshire and one from Monmouthshire. Similar widening in sources of supplies was evident in 1936. Total sales were 1,031 and sixty-three of these were from Glamorganshire, eighteen from Breconshire, sixteen from Pembrokeshire, two from Monmouthshire, three re-sales by London and Lancashire buyers and all the rest were from the counties of Cardigan and Carmarthen. The outstanding features of the market, so far as supplies are concerned, are its heavy reliance on what may be called local supplies and the tendency for Glamorgan to supply a larger number of horses each year. None of the more distant counties seem to specialise in supplying any particular types of horses, for the supplies are distributed between all the classes without showing definite trend in any of them.

The area from which buyers are attracted has been expanding to some extent, and as the market grew the proportion of supplies passing outside the local area increased. In the earliest year, four-fifths of the supplies remained in the locality, and the market was mainly a local exchange. Four years later nearly half the supplies went to England, and that proportion continued to increase to 1934 and then decreased. The following are the main proportions for the different years.

		Local.	*Glamorgan.*	*England.*
1920	..	157	28	53
1924	.	228	12	228
1926	...	220	12	319
1934		241	101	109
1935		350	129	418
1936	...	384	190	427

The chief destinations are shown by the Table, but on two occasion horses have been sent to Scotland, and supplies have gone to twenty-five counties outside Wales.

In 1936 local buyers, buying mainly for breeding and carrying forward, purchased 384 and Glamorgan buyers displaced Londoners as the next biggest buyers. This was due to the heavy increase in the purchases of cart horses, mainly for use in collieries despite the misleading title given them. London buyers took 164 mostly cobs but with a high proportion of cart horses and some of the collier type. Buyers from Gloucester took ninety horses mainly of cart type but with some vanners amongst them :

Lancashire, Warwick, Kent and to a lesser degree Shropshire, Hereford and Derby were the other substantial buying areas. New buying areas were Dorset, Buckinghamshire, Oxford and Essex. Thus the areas from which buyers came to the market showed continued expansion and more and bigger buyers came from some of the older buying areas. Local buyers were the most

TABLE IV.

Destination of Horses Sold. (All types and classes).

Area or Place.	*1920*	*1924*	*1926*	*1934*	*1935*	*1936*
Wales:						
Local	157	228	220	241	350	384
Glamorgan	28	12	12	104	120	190
Monmouth	—	—	2	12	8	14
Pembroke	1	1	1	2	7	7
Brecon	3	—	7	4	8	7
Montgomery	1	1	—	—	2	1
Merioneth	—	—	—	—	3	—
Caernarvon	-	—	—	1	1	1
Total	190	242	272	364	499	604
England.						
London	1	99	152	192	130	164
Gloucester	11	5	21	81	116	90
Lancashire	5	5	4	66	68	31
Kent	5	64	65	29	37	26
Warwick	—	—	—	10	5	29
Cambridge	4	24	58	6	—	5
Hereford	—	—	—	2	30	17
Cheshire	6	—	6	1	3	19
Salop	2	—	4	10	8	10
Sussex	—	13	5	2	—	8
Berks	—	12	—	-	—	5
Northampton	—	1	1	2	11	2
Derby	—		—	—	—	12
Lincoln	10	—	—	-	1	—
Surrey	2	1	—	3	2	1
Somerset	—	-	—	4	1	3
Other English Counties (8)	1	1	3	1	6	5
Total	53	228	319	409	418	427
Scotland:						
Glasgow	—	5	—	1	—	—
Grand Total ...	243	475	591	771	917	1,031

important in all years when the term "local" comprises the whole of the counties of Carmarthen and Cardigan. Of the remaining buying areas in Wales, Glamorgan has been far the most important in all years and the expansion in purchases in the years 1934, 1935 and 1936 has been quite remarkable, due mainly to the increased demand for pitters. Buying areas out-

side Wales have gradually become relatively less important as regards total purchases than areas inside Wales and in 1936 for the first time since 1924 more of the total horses sold stayed inside the Principality than went outside of it. This illustrates the recent heavy dependence of the market on purchasers who are buying horses for breeding and for use in coal mines. Thus the market may be said to be highly vulnerable to conditions in the coal mining industry.

Prices.

It is difficult to obtain any general information on the prices of horses, for there are no regular market quotations. The records of prices realised in the sales under consideration are good, but they do not, of course, contain any statements as regards quality of horses from time to time, and the classification is not without some uncertainties. In the absence of other information on prices of horses, the Table showing average prices for different classes over six years is of great interest.

Price movements of all classes were downwards in the early period reaching the lowest levels in 1924 or 1926, except prices for ponies which were lowest in 1934. Nothing could have been more disastrous in any branch of the livestock industry than the precipitous decline in prices of horses after 1920.

Cobs and Ponies.—Cobs had declined considerably in value by 1924 and by 1926 were worth less than half of their values in 1920. Some little improvement had occurred in their prices by 1934, continued in 1935 and 1936 until in the latter year they were about 33 per cent. higher than prices in 1926. The relative fall in the prices of ponies was even greater, having declined to considerably less than half of the 1920 values by 1924 and less than a third of 1934 and 1935. It is probable that the quality of ponies offered for sale had deteriorated by this time for there was no price incentive to breed them and thus the low price is partly due to weak demand and partly due to deterioration in quality. Some improvement occurred in 1936 and prices were a little over a third of the 1920 level.

Vanners.—Prices of Vanners fell precipitously from 1920 to 1924 when horses of this class were worth less than half the 1920 values. Since that year the demand for this type of horse has increased; the prices have improved steadily and in 1936 were about 60 per cent. above those of 1924. Price movements in the other classes of light horses cannot be ascertained with any

degree of certainty for the horses in these classes were a heterogeneous lot.

Cart Horses.—Prices of cart horses had fallen by 1924 to little more than a third of the level of those of 1920. Some

TABLE V.

Prices of Horses sold.

Class.	*1920*			*1924*			*1926*			*1934*			*1935*			*1936*		
	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
Light Horses.																		
Cobs	41	11	0	28	7	0	20	0	0	21	15	0	25	6	0	26	6	0
Ponies	35	5	0	14	8	0	14	6	0	9	13	0	9	16	0	13	0	0
Vanners ...	50	18	0	22	15	0	24	16	0	31	5	0	33	1	0	36	7	0
F.F. and Colts ...	28	12	0	4	7	0	3	15	0	10	18	0	11	5	0	12	3	0
Mares and Fools ...		—			—			—			—			—		34	0	0
Others		—		27	15	0	10	2	0	8	4	0	18	18	0		—	
Heavy Horses.																		
Cart	66	14	0	24	7	0	25	7	0	30	16	0	36	2	0	37	13	0
Colliers	58	19	0	24	5	0	23	14	0	28	17	0	29	10	0	31	19	0
F.F. and Colts ...	44	0	0	13	17	0	11	6	0	21	4	0	17	17	0	24	4	0
Mares and Foals ...	45	5	0	22	17	6		—		27	0	0	19	10	0		—	
Others	13	0	0	6	10	0	10	19	0	6	18	0	14	17	0	11	15	0

improvement occurred in 1936, and further improvemnet in 1934, 1935 and 1936. Still prices had only risen in 1936 by about 55 per cent. above the 1924 values.

Colliers.—Prices of colliery horses suffered a like fate reaching their lowest level, which was between a half and a third of their 1920 value, in 1926. Subsequent improvements raised the level of prices for 1936 to a little over half that of 1920 and 33 per cent. above the lowest price recorded.

Other Horses.—Prices of the other classes of horses of the heavy type showed practically the same trend but owing to the heterogeneous nature of the types, fillies, foals and colts and others, no very great degree of reliability can be claimed for the prices shown for them and numbers of mares and foals sold in the market were too few to make the price figures representative.

Taking the years 1920 and 1936 as representative of the periods of peak prices and recovery of prices and further taking the average value of a cart horse as standard the following relative values by main types of horses sold were operative.

This simplified statement shows that cart horses were absolutely and relatively more valuable in 1920 than in 1936. Vanners and cobs have shown distinct relative gain in price when compared with those of cart horses the most pronounced gain having taken place in the prices of vanners for they were

Type.	*Price in 1920 to nearest £*	*Ratio.*	*Price in 1936 to nearest £.*	*Ratio.*
Carthorses	67	100	38	100
Colliers ...	59	88	32	84
Vanners ...	51	76	36	95
Cobs ...	42	63	26	70
Ponies ...	35	52	18	84

95 per cent. as valuable as cart horses in 1936 and this cannot be attributed to small numbers of sales for over 100 were sold. Prices of ponies had lost considerable ground in the relative sense by comparison with 1920 while those of colliers showed little change.

If yearly changes in prices of horses in relation to changes in the value of money were displayed it would be found that values of horses dropped more rapidly than general prices between 1920 and 1926 and have since shown greater recovery.

Conclusions.

The expansion of the West Wales horse sales is a remarkable feat of marketing in a period when the horse population of Wales and Monmouthshire has been declining. Supplies have been drawn in the main from local sources and distant supplies have assumed only relatively small significance. In fact the movement of cobs, cart and colliery horses from the more distant counties into the West Wales district is mainly one of stock which may be used for breeding shifting from the farms near industrial areas to a region where there is a ready sale for them. Local buyers are in the main interested in purchasing breeding or maturing stock. The market began as a local exchange centre and not only have local supplies continued to be predominant but local purchases sustained this market in its early years. More recently the destinations to which horses have been dispatched have shown considerable expansion and in this way the " width of the market " has shown considerably greater capacity for creating increased business. This expansion was maintained in 1936 and the market was able to dispose of the finished products of the district in still greater numbers. But numbers disposed of inside Wales showed significant increase and should demand from Glamorgan show a decline as a result of slackening of industrial activity, or of machinery displacing horse labour in coal mines and associated trades, the market for heavy horses

in the district will be very adversely affected, for a horse market such as that at Llanybyther must rely for success very largely on a distant market for its finished mature horses at, say, five years old. The fact that distant buyers still patronise the market as much and take as large numbers as at any time in its history is a proof that they are prepared to face keen competition from demands originating nearer the market. Welsh buyers have been purchasing increasing numbers of horses of heavy types while more distant buyers have not been able to increase total purchases to any significant degree in the years 1935 and 1936. The more extensive character of distant buying has been far more significant than any increase in actual numbers of horses bought.

The relationship of numbers of horses sold in the auction ring to actual entries is surprisingly low and it can be readily appreciated that the cost strain thrown on a marketing system subject to this uncertainty must impair its economic efficiency. But the fact that the rate of sales to total entries tends to be highest in the spring selling period and to a much less marked extent in the autumn selling period tends to show that the bigger sales suffer less from this uncertainty than the smaller ones and they are better patronised by buyers. The entry of horses for sale without reasonable certainty of the entry appearing in the sale ring is a bad thing for the vendors generally and the sooner they realise this the better it will be for all concerned with orderly marketing.

Proper description of animals when entering is also important for it is practically impossible for salesmen to organise sales to the best advantage when sellers resort to inaccurate descriptions of animals. Sellers must lose by the adoption of this practice. Classifying becomes a purely arbitrary process and results in splitting buyers when more than one ring is operated, for it will be found impossible to sell by types. One of the main needs of the horse trade in this market is better and firmer classing for in most other respects the organisation is adequate and effective. And this should be relatively easy for the main trade is in cart horses, colliers, cobs and vanners which are all sufficiently distinct to the trained horse salesman.

Prices moved against sellers in the market in the first period as they did everywhere, but became slightly more favourable in the latter period studied. There were differences in the relative values of the various types of horses in the peak year 1920 and

those of the recovery year 1936. Cart horses, colliers, and ponies lost in value by comparison with vanners and cobs. The latter classes have shown considerable relative gains but these differ in different years as reference to the appropriate Table will show.

There can be no question that this market has provided an important outlet at reasonable prices for the horses of the wide area it serves. Further, that outlet has been provided and maintained during a time when the horse trade as a whole could scarcely have fallen on more distressing times.

THE OPERATION OF THE MILK MARKETING SCHEME IN WALES, 1936-37.

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The division of labour and specialisation of function which is a characteristic feature of the present economic system has resulted in the activities of production and consumption appearing as two separate processes. Before goods reach consumers they have to be exchanged and this necessarily involves a market valuation. Throughout the nineteenth century when markets were expanding and even until comparatively recently it was, perhaps, true to say that this valuation process, both in the agricultural and industrial spheres, was left as nearly as possible to the free-play of economic forces. Market prices were left to be determined by the interactions of demand and supply under more or less competitive conditions, while it was believed that the fact of competition was sufficient both to allow of a fair price to the consumer and to ensure a reasonable return to the producer. But during recent years many factors have contributed to the partial breakdown of this system. Increase in the efficiency of production has been general and has proceeded at an accelerated pace. The geographical area under man's economic control has continued to expand, while the international trade of Great Britain and in particular the complementary nature of her trade with certain areas of " new " settlement with whom she has special political relations are of deep significance both to the producers and consumers of this country. The harmonious working of the present economic system depends on the ability of producers to sell their products at prices which

yield reasonable profits, which in turn depends on the possession of sufficient purchasing power by consumers to command them at these prices. But the great increase in physical output on the supply side, and in some cases the lack of purchasing power on the demand side set in motion forces which tended, especially at certain periods, to reduce prices to uneconomic levels. And these conditions have gradually led to the partial breakdown and to the supersession of the old system of unrestricted competition. In the industrial field the alternative was found in national and even international price-fixing arrangements and sometimes in agreements to limit output, which first made their appearance in this country in the latter years of the nineteenth century. But in agriculture no such policies were universally adopted, and the absence of associations or institutions regulating competition intensified the susceptibility of the prices of agricultural products to fall to very low levels owing to the many obstacles to rapid expansion or contraction which the departments of this industry meet. Such was the plight of the dairy industry of this country during the opening years of the present decade that a scheme for the marketing of milk was set up under the Agricultural Marketing Acts of 1931 and 1933.

The England and Wales Scheme commenced operations in October, 1933, and the Scottish Schemes and that for Northern Ireland followed soon afterwards. The dairy industry of this country has therefore experienced four complete years of organised marketing. The two previous issues of this *Journal* [1] contained reviews of the operation of the Milk Marketing Scheme in Wales during the second and third contract years, so that the following account deals mainly with the contract year 1936-37, although it will be useful to refer to data for the Welsh and other regions, and for England and Wales as a whole for this and previous contract periods in order to obtain a better understanding of the progress of the Scheme and its effects on the milk producers of Wales.

A good indication of total milk production is furnished by the size of the dairy herd. In England and Wales numbers of dairy cows [2] increased from 2,537,000 in 1933 to 2,632,000 in 1936, but in 1937 the number had fallen to 2,609,000, which represented a decrease of 0.9 per cent. In North Wales there was a reduction of 0.7 per cent. from 122,800 in 1933 to 121,900 in 1936 and a further reduction to 120,200 in 1937. In South Wales there was an increase of 4.1 per cent. between 1933 and 1936,

[1] See Vol. 12 (1936) pp. 86-97 and Vol. 13 (1937) pp. 94-107.
[2] Cows and Heifers in Milk and Cows in Calf.

numbers being 171,800 and 178,800 respectively; by the following year, however, there was a very small reduction to 178,300.

Although the total milk produced in England and Wales has not passed through the Scheme, the proportion is sufficiently high for the trend in sales to reflect changes in the size of the dairy herd. In England and Wales sales under wholesale contracts increased annually from 716,487,000 gallons in 1933-34 to 899,551,000 gallons in 1935-36. But following the trend in the size of the dairy herd the quantity had fallen to 867,864,000 gallons in 1936-37 which represented a decrease of 3.5 per cent. The position has been somewhat similar in North Wales, total contract sales having increased from 13,861,000 gallons in the first contract year to 19,354,000 in 1935-36, and fallen slightly to 19,157,000 gallons in the following year. In South Wales, however, the size of the dairy herd increased steadily between 1933 and 1936, and in 1937 numbers showed little change over the previous year, while sales under wholesale contracts have showed continuous increases. The latter increased from 24,605,000 gallons in 1933-34 to 36,032,000 gallons in 1935-6. In the following contract year they had increased by 3.8 per cent. to 37,410,000 gallons. The corresponding gallonages for the West Midland increased from 63,909,000 in 1933-34 to 79,453,000 in 1935-36, but fell to 76,406,000 in 1936-37. But the decrease in total contract sales in England and Wales during the last year has been general, while it is remarkable that the only regions which showed increases during this period were the South Wales and the Eastern. The general position is shown in the following Table.

TABLE I.

Changes in Sales: Increases and Decreases from previous year.

	1936-37. over 1935-36.			
	North Wales.	*South Wales.*	*West Midland.*	*All Regions.*
	%	%	%	%
Total Contract Sales	— 1.0	+ 3.8	— 3.8	— 3.5
Liquid Sales ...	+ 6.4	+ 22.8	+ 8.9	+ 3.8
Manufacturing Sales	— 7.6	— 18.5	— 14.8	— 15.5

Changes in farmers' production policies are in the last instance accounted for by the prices received for a particular form of agricultural output relative to those which may be obtained

for other forms of production for which their farms are suited. The prices received for milk during the last contract year will be considered at a later stage. It may be mentioned, however, that the favourable conditions in the markets for fat and store cattle during the last twelve months might have caused those livestock producers who entered the milk market in the opening years of the Marketing Scheme, owing to relative price advantages, to return to their pre-Scheme activities. There has also been quite an appreciable increase in the prices of feeding-stuffs. These comprise on the average between 25-30 per cent. of the total costs of milk production.

In order to ensure the optimum returns to producers a sharp distinction has been maintained between the prices charged to buyers for milk for liquid consumption and that which is used for manufacture, while the prices for that consigned to the latter market also vary according to the purposes for which it is utilised. During 1936-37 the nominal prices for liquid milk remained unchanged from the previous contract at 15s. 3d. per dozen monthly gallons. As regards liquid sales there was an increase of 3.8 per cent. in England and Wales over the corresponding contract. Every region contributed towards this increase with the exception of the South-Eastern and Far-Western regions. It will be observed from Table I that the increase in liquid sales in Wales and in the West-Midland region, and especially in South Wales, were appreciably higher than in the country as a whole.

But the average realisation value for liquid milk over the year depends on the seasonality of sales, that is, on the relative proportions sold in the high and low priced months respectively. On this basis the weighted average contract price for liquid milk for England and Wales was 15.21d. per gallon as against 15.23d. in the previous year. The corresponding values for the North and South Wales regions for 1936-37 were 15.19d. and 15.03d. per gallon respectively. But these weighted average "nominal" prices for liquid are reduced somewhat owing to the lower price received for milk sold under the Milk in Schools Scheme. This Scheme provides for the sale of milk to schoolchildren and members of certain other approved centres at the reduced price of ½d. per one-third pint bottle, provided that the milk is actually consumed in the schools or the approved centres. Since the inauguration of the Scheme in October, 1934, the total quantity of milk sold in this way has continually increased, the actual gallonages being 22,854,000, 21,916,000 and 28,004,000 in the

last three contract years respectiveely. The Exchequer contributions in these same years amounted to £401,872, £397,848, and £410,151 respectively which work out at roughly 4¼d. per gallon.

The proportions sold to the liquid and manufacturing markets have an important bearing on the average returns to all producers in the aggregate, although the regional pool prices are not allowed to vary unduly as a result of the different proportions which go to the manufacturing market in different regions and the different realisation values of the milk consigned thereto. During the last contract year for the first time since the institution of the Scheme the quantity of milk which was used for manufacture in England and Wales was less than that for the preceding year, the actual decrease amounting to 53,260,000 gallons or 15.5 per cent. The quantity manufactured in 1936-37 was also 4.1 per cent. lower than that for the contract year 1934-35. The comparative positions of Wales and the West-Midland region and of the country as a whole are given below.

TABLE II.

Proportions used for Manufacture

	1934-35.	*1935-36.*	*1936-37.*
	%	%	%
North Wales ...	52.50	53.05	49.50
South Wales ...	37.97	46.01	36.11
West-Midland	54.18	53.62	47.49
All Regions ...	35.34	38.07	33.29

It has been observed above that a smaller quantity was manufactured in every region in 1936-37 than during the previous contract. The proportions manufactured were also lower in every region with the exception of the Far-Western in which region there was a slightly greater proportionate reduction in liquid sales. It is seen from Table II that the proportions manufactured in Wales and the West-Midland and in the country at large during the last contract year were also somewhat lower than in 1934-35. The regional figures were, however, still somewhat higher than the national average during 1936-37, especially in the case of the North Wales and the West-Midland regions.

This expansion in liquid sales and the consequent diminution in the proportions manufactured may be attributed to some increase in demand for milk for domestic and "foodshop" consumption; increase in sales to buyers without manufacturing licenses, increase in school milk and some other special schemes

like factory supplies, and some increase due to milk bars. It is seen from Table I that liquid sales in South Wales increased by almost a quarter during the last contract year, while the increases in the less industrialised North Wales and West-Midland regions, although quite considerable, did not approach such dimensions. But most of this increase in South Wales was consumed outside that region. Figures for liquid sales do not deal with consumption, but only with sales at liquid prices and in the case of buyers without manufacturing licenses there is no certain knowledge of uses.

The milk which goes to the manufacturing market is sold on a class-use basis. Therefore the value which it realises depends on the proportions which go to the separate categories. The percentage utilisation of manufacturing milk in the Welsh regions and in the country at large for 1936-37 and the average values realised for the different classes of products are given in Table III.

It is seen from the Table that milk which goes to make butter and hard cheese brings in a very low return, the average realisation values for such milk being 4.15d. and 5.47d. per gallon respectively Yet these values were somewhat higher than those realised during the preceding contract, the increases being slightly

TABLE III.

Utilisation of Milk for Manufacturing Purposes, 1936-37.

Products.	*Percentage of Total.*			*Average Utilisation Value per gallon.*
	North Wales.	*South Wales.*	*All Regions.*	
	%	%	%	Pence.
Butter	45.01	51.60	34.21	4.15
Hard Cheese ...	50.09	25.85	18.65	5.47
Soft Cheese ...	—	—	0.36	7.50
Stilton Cheese ...	-	—	1.41	6.47
Condensed Milk (Home)	2.13	5.89	19.27	6.85
Condensed Milk (for export) ...	--	—	2.97	5.48
Milk Powder ...	—	7.78	2.73	6.35
Fresh Cream ...	2.76	4.77	15.54	7.50
Bottled Cream ...	—	0.75	0.18	7.50
Tinned Cream ...	—	3.18	3.31	6.83
Ice Cream	0.01	—	0.14	7.50
Sterilised Milk for Export	--	—	—	6.00
Other Goods ...	—	0.18	1.23	9.00
Total or Weighted Average ...	100.00	100.00	100.00	5.75*

* Excluding Subsidy. Including Subsidy 5.80d.

under ½d. per gallon in the case of butter and rather over 1d. per gallon for cheese. The prices of milk for condensing and for conversion into milk powder were rather higher than those obtained for the two former categories, and have also advanced a little over 1935-36. Prices of the cream classes and of that group designated "Other Goods," which are among the higher categories, have remained unchanged.

In England and Wales during the last contract year about a third of the milk which was surplus to liquid requirements was used for making butter, and slightly under one-fifth for cheese manufacture. The lower priced categories therefore claimed just over a half of the total manufacturing sales as against 61 per cent. in 1935-36. About a quarter was used for conversion into condensed milk, while about one-fifth went into the cream class. The corresponding proportions during the previous contract were 19.6 and 14.4 per cent. respectively.

In North and South Wales, on the other hand, the proportions which were used for manufacture into butter and cheese were very much higher than in the country at large. In the former region these two categories accounted for 95 per cent. and in South Wales for over 75 per cent. of the total manufacturing sales in 1936-37. The proportions which went into the higher categories were therefore very low, especially in North Wales. In the West Midland region about half of the surplus milk was used for the manufacture of butter and cheese, about 42 per cent. for condensed milk for home consumption and the remainder for cream and "Other Goods."

The weighted average realisation value of manufacturing milk in England and Wales during 1936-37 was 5.75d. per gallon, which represented an increase of 0.80d. over the previous year. The better utilisation of supplies and the more favourable prices of certain categories have both contributed to this increase. As would be expected, however, the average realisation values in North and South Wales were somewhat below the national average, the actual values being 4.96d. and 5.08d. respectively. In the West Midland, however, higher proportions of the manufacturing milk were utilised in the more remunerative classes, and the average value realised therefrom was ¼d. above the general average. But the returns from the sale of manufacturing milk are pooled for the whole of England and Wales and each region is credited with the same amount per gallon. The milk producers of North and South Wales were therefore very fortunate in this respect as the actual values realised for their surplus milk were

lower than the national average. During the last contract year about £31,000 was paid into the North Wales regional pool in excess of the market value of its manufacturing milk, while South Wales benefitted to the extent of nearly £88,000. But the subsidy payable under the Milk Acts of 1934 and 1936 amounted to an additional 0.05d. bringing the total value credited to each region up to 5.80d. per gallon, which was 0.85d. above the corresponding figure for 1935-36. The total benefit to the milk producers in the North and South Wales regions (inclusive of subsidy) therefore amounted to approximately £88,000 and £40,000 respectively.

Throughout the contract year 1936-37 the contributions which producer-retailers were required to pay towards the maintenance of the pool prices of their respective regions were still determined according to a formula based broadly on the differences between the contract prices for liquid milk and the regional pool prices. The size of the pool deductions were therefore of importance to this class of producer. The unweighted average deductions for North and South Wales and for the West-Midland region along with the averages for the country as a whole for the last three years are given in the following Table. The producer-retailers of South Wales obtained considerable benefit from the increased proportion of the region's milk which was sold as liquid—largely for distant consumption.

TABLE IV.

Yearly Average Pool Deductions.

Year.	*North Wales.*	*South Wales.*	*West Midland.*	*All Regions.*
	d.	*d.*	*d.*	*d.*
1934-35	3.18	2.73	3.31	2.88
1935-36	3.77	3.58	3.83	3.54
1936-37	3.31	3.10	3.33	3.03

It is seen from the Table that the national and regional deductions for 1936-37 were round about ½d. per gallon below those for the previous year, although they were still somewhat above those for 1934-35 and considerably above the average for the first year of the Scheme. The deductions for the Welsh and West-Midland regions have, however, been consistently above the averages for England and Wales.

These figures give a clue to the level of producer-retailers' contributions over the whole country and the relative positions of the regions with which we are concerned. As would be expected

the producer-retailers' gross levies were lower during 1936-37 than for the previous year, the actual reduction being 0.47d. per gallon. Those for North and South Wales and the West-Midland regions also showed the same trend, the decreases being slightly under ½d. in each case. The monthly gross rates of levy for the Welsh regions and for the country at large are given in the following Table.

TABLE V.

Producer-Retailers' Levies, 1936-37.

Month.	*North Wales.*	*South Wales.*	*All Regions.*
	Pence per gallon.		
October	3.75	3.75	3.62
November	3.25	3.06	3.03
December	2.62	2.68	2.52
January	2.80	2.68	2.59
February	2.80	2.68	2.57
March	3.06	2.88	2.82
April	3.31	3.12	3.16
May	2.56	2.38	2.34
June	2.50	2.31	2.26
July	2.75	2.56	2.48
August	2.31	2.31	2.19
September	2.50	2.12	2.21
Unweighted Average ...	2.85	2.70	2.65

But producer-retailers may also qualify for the level delivery premium which was fixed at 1d. per gallon throughout the last contract year, and also for the special quality premiums. The net levies were therefore rather less than the values given above, although they cannot be given as proportions are unknown.

Most of the factors which enter into the determination of the pool prices have now been considered. Reference must be made, however, to the Inter-Regional Compensation Levy which affects the regional pool prices but not the average returns over the whole country. This is a levy on all liquid sales and the sum built up from its proceeds is re-allocated among the different regions so as to assist in the elimination of any undue disparities in the regional pool prices. During 1936-37 this levy varied between 1d. and 2¼d. per gallon. Both the North and South Wales regions and the West-Midland have hitherto, by reason of their special characteristics, received on balance net contributions from this fund, the actual amounts for 1935-36 being £61,558, £18,428 and £299,421 respectively. The allocations for 1936-37 are not available but as conditions in these regions

have not fundamentally altered it may be said that they also gained from this fund during the last contract year, but that North Wales gained much more than South Wales.

As regards the pool prices it has been observed that liquid sales constituted a slightly higher proportion of total contract sales during 1936-37 than in the previous year, although the actual realised value was almost identical, while there was quite an appreciable increase in total receipts from manufacturing milk. The weighted average pool price for England and Wales worked out at 11.99d. per gallon which represented an increase of ½d. over the previous year. As would be anticipated the corresponding values for the Welsh regions and for the West-Midland worked out at a slightly lower level, although they were, as in the case of the country as a whole, approximately ½d. per gallon above those for 1935-36.

A summary of the chief results of the Scheme for 1936-37 is set out in Table VI.

TABLE VI.

Contract Prices, Realisation Values, and Pool Prices, 1936-37.

	North Wales	*South Wales.*	*West Midland.*	*All Regions.*
	d.	*d.*	*d.*	*d.*
(1) Contract Prices for Liquid Milk ...	15.25	15.25	15.25	15.25
(2) Weighted Average Prices Liquid Sales	15.19	15.03	15.20	15.21
(3) Weighted Average Prices All Contract Sales ...	14.84	14.86	14.94	15.08
(4) Average Utilisation Value for Manufacturing ...	4.96	5.08	6.01	5.75
(5) Credited to Region (excluding Subsidy) ...	5.75	5.75	5.75	5.75
(5) Credited to Region (including Subsidy) ...	5.80	5.80	5.80	5.80
(7) Weighted Average Pool Prices ...	11.56	11.80	11.63	11.99

The increase in liquid consumption noted above has been achieved in spite of an increase in consumers' prices. It has been estimated that consumption per head per day in England and

Wales has increased from 0.379 pints in 1933-34 to 0.42 pints in 1936-37. The milk sold by licensed producer-retailers during the last contract year has, however, been estimated to be lower than that for the previous year by some 3,000,000 gallons, the actual figures being 118,000,000 and 115,000,000 gallons respectively. There were considerable increases in milk sold liquid by wholesale producers, and in the amount of Tuberculin Tested milk not sold under the Scheme. The publicity campaign has no doubt served to increase consumption, while the numbers of milk bars continue to increase. In September, 1937, there were 947 milk bars in England and Wales. South Wales contained 26, of which 18 were in Glamorgan, and North Wales 28, of which 19 were in Denbighshire.

In order that the full advantages accruing from the fixation of monthly contract prices for liquid milk might be realised it has been deemed desirable to lay down in addition minimum prices at which such milk and that of producer-retailers may be sold to the final consumers. These are based partly on the population of and partly on the form of local government authority by which a particular town or division is administered, the only connection with the regional structure of the Scheme being the retention to some extent, of the South-Eastern region as a distinct area. The minimum retail prices for these separate divisions from 1934-38 are given below.

TABLE VII.
Minimum Retail Prices.

	Per Twelve Monthly Gallons.	
	1934-37.	*1937-38.*
	s. d.	*s. d.*
(1) All Rural Districts, and Urban Districts, and Municipal Boroughs of less than 10,000 inhabitants	23 4	**24 4**
(2) Urban Districts, Boroughs and County Boroughs with a population exceeding 10,000 but under 25,000	25 0	**26 0**
(3) Urban Districts, Boroughs and County Boroughs outside the South-Eastern Region with a population exceeding 25,000	26 0	**27 0**
(4) Urban Districts, Boroughs, and County Boroughs within the South-Eastern Region with a population exceeding 25,000 including the City of London and the Metropolitan Police District	26 8	**27 8**

During the first contract period which extended from October 1933, to March 1934, no provisions were made for fixing minimum

retail prices, the only stipulation being that milk was not to be sold at less than the retail prices prevailing in each district. But during the next contract period which expired on September 30th, 1934, minimum retail prices were set out and although they were not strictly comparable with those fixed for later contracts owing to a change in the classification of districts, it appears that they were rather lower than the prices fixed in the succeeding contracts.

It is seen from Table VII that these prices remained unchanged during the years 1934-37. But this must not be taken to imply that consumers' prices remained stationary throughout this period, as these were merely the minimum prices below which no retailer was to sell. Retailers could sell at higher prices, and by mutual agreement and the sanction of the Board those minimum prices might be reduced in specified areas for which agreements were made. In spite of some reductions from the contract minima there was a tendency towards increase. The average retail prices for England and Wales and the relative increases in large and small towns are set out below.

TABLE VIII.

Actual Retail Prices: England and Wales.

	Average Price per quart (pence).*	*Index Numbers.*		
		Large Towns.	*Small Towns.*	*Total.*
1933-34	6.0	169.3	177.5	175.2
1934-35	6.3	177.2	184.8	180.9
1935-36	6.4	178.8	185.9	182.3
1936-37	6.4	178.9	186.3	182.4

* July, 1914 = 3½d = 100.

In 1932-33 the average retail price was 5.8d. per quart, so that the advance in the meantime has been in the region of ½d. per quart. Those in small towns have risen somewhat more than have prices in large towns, the percentage increases since 1932-33 being 27.4 and 24.1 respectively. The continued increase in retail prices is a rather unfortunate feature. It is true that the consumption estimates show an upward trend, but the reputed increase has been very slight in relation to the efforts to popularise milk and the increase in working class purchasing power. Events to date may not point to marked elasticity in the demand for milk, but over the long period demand is very elastic and further price increases may well nullify the advantages of special efforts through the medium of assisted sales or otherwise to

increase liquid consumption. Moreover, any substantial increase in consumption will only be achieved through a rising appreciation and a greater effective demand for milk among the general body of consumers.

Numbers of accredited producers continue to increase, although the rate of increase is now much smaller than formerly. In October 1937, there were 21,111 producers on the accredited roll, which was 2,181 above that of October 1936, and represented an increase of 11.5 per cent. But during the previous corresponding period the increase amounted to 69 per cent. The proportions of accredited producers in the North Wales and West-Midland regions have remained approximately unchanged during the last contract period, but the proportion in South Wales has increased by about one per cent. and actual numbers by about 23 per cent. The accredited levy averaged 0.347d. per gallon over the year.

TABLE IX.

Numbers and Proportions of Accredited Producers.

	North Wales.		*South Wales.*		*West Midland.*		*All Regions.*	
		%		%		%		%
October, 1936 ...	802	4.2	825	4.3	1,365	7.2	18,930	100.0
July, 1937 ...	841	4.0	1,081	5.2	1,441	6.9	20,835	100.0
October, 1937 ...	861	4.1	1,118	5.3	1,458	6.9	21,111	100.0

During the year 1936-37 some important amendments were made in the Scheme, but they mainly affect its results in 1937-38. Producers with four cows or less and those who sell Tuberculin Tested milk now have to register with the Board. Previously those four-cow producers who sold wholesale were exempt while those who sold retail had the option of paying the appropriate levies on their sales or 10s. 0d. per cow per year. The " standard transport deductions " on manufacturing and depot milk which varied with individual producers have been replaced by the " standard freight deductions " which have been standardised for different regions. Those for the Welsh regions at 1.65d. per gallon are at the highest level, the other regions with similar deductions being the Northern and the Far-Western. That for the West Midland is 1.35d., while the South-Eastern has the lowest at 1.1d. It is worth noting, however, that the weighted average transport charges for North and South Wales for 1934-35 were 2.09d. and 2.58d. per gallon respectively. According to the

new arrangements all producers within a given region will have the same deductions except for collection charges, while the 1937-8 contract also includes an important clause regarding this latter charge.

The Board is also empowered to transfer milk from the manufacturing to the liquid market and from the lower to the higher class products within the former market if shortages occur in the supplies available for the higher priced categories. The normal activities of some farmers' co-operative enterprises in Wales have been affected during the last Winter by this arrangement, but it must be remembered that the intention is to increase producers' returns.

The nominal contract prices for liquid milk have been increased to 15s. 11d. per dozen monthly gallons and 17s. 11d. for Tuberculin Tested milk sold as such, while the increases in the minimum retail prices have already been noted. Producer-retailers' levies have been standardised at 1¾d. and 2¼d. per gallon for ordinary milk sold on the level and non-level contracts respectively but decreasing with each step of "graded" milk. A reduction of ¼d. a gallon is made off these rates for prompt payment. Wholesale producers receive corresponding premiums for quality milk. This is a desirable feature and is in accord with that part of the Government's *Milk Policy* [3] for improving the standard of supplies. In general this has been stated to be to ensure "maximum supplies for the consumer at fair prices consistent with reasonable remuneration for the producer," and this will be best achieved through the realisation on the part of the authority in whom the power of price-fixing is nominally vested of the consumer-reactions to the prices they may fix.

AN ENQUIRY INTO CAUSES OF PROFITS AND LOSSES IN EGG PRODUCTION.

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A wide range of profitableness in individual enterprises which are comparable in several of their chief features seems to be characteristic of poultry farming. Economic studies of the industry have been mainly confined to commercial egg production but the units have varied from backyard flocks to well

[3] Cmd 5533, 1937.

managed specialist flocks on general farms and also to large specialist units operated by managers having no other agricultural interest. So far as can be judged from collected records there is no definite positive or negative relationship between profitableness and the chief types of commercial unit. The most common explanations of the variations in the amount of the profit earned are differences in costs of foods, in prices of eggs and in the rates of deaths and general depreciation. Other suggested causes are differences in yield per bird, in the cost of labour per bird, and also in variations in the size of the laying flock within the different types. Most people would hazard the opinion that a high degree of positive relationship would be found between costs of foods and profitableness. There is also the expectation of a positive association between prices of eggs and profitableness and possibly most farmers would be of the opinion that costs of foods and prices of eggs would account for 75 per cent. of the variations. With the tendency for farmers to focus their attention on yields it is certain that they would declare in favour of high yields being associated with high profits. This would be the case where experiences had impressed upon them the close relationship between yields and the health of birds. It is a common and well founded opinion that a high death-rate is associated with unfavourable financial results.

While farmers' lists of causal factors do not often extend beyond cost of foods, prices of eggs, yields and disease, those of economic investigators have covered a wider field. They have suggested a fairly close association between size and profitableness of units Conditions of economy of labour, economical lay-out of unit and the ratio of investment in capital equipment to investment in livestock are expected to be associated with size of unit. Each of these would be underlined as likely to show important positive relationships with profits. In view of these opinions it is interesting to examine several of the more important causal factors in some detail.

Profits and Cost of Foods. Information collected over a period of four years indicates that the changes in the average price paid for poultry foods are not of the same order as those shown for individual classes of foods. It has been suggested[1] that as costs of feedingstuffs increased by 35 per cent. in a recent period this added 20 per cent. to the poultry farmers' total costs

[1] See *Journal* of Ministry of Agriculture and Fisheries, Vol. XLIV, No. 10, pp. 971-2. (January, 1938).

because this item forms about 60 per cent. of such total. But in a group of flocks in Wales a very different position was found.

Cost of Poultry Foods.
Per cwt.

	1935-36.	1936-37.	Increase on 1935-36.
	s. d.	s. d.	%
Mashes ...	9 7	10 1	5.2
Wheat ...	7 4	9 7	30.7
Maize ..	6 0	7 4	22.2
All Foods ...	8 3	9 3	12.0

The small increase shown in the costs for all feedingstuffs is explained by the farmers' efforts to reduce the effect of rising prices by making heavy reductions in the purchases of mash and an increase in the quantities of maize used.

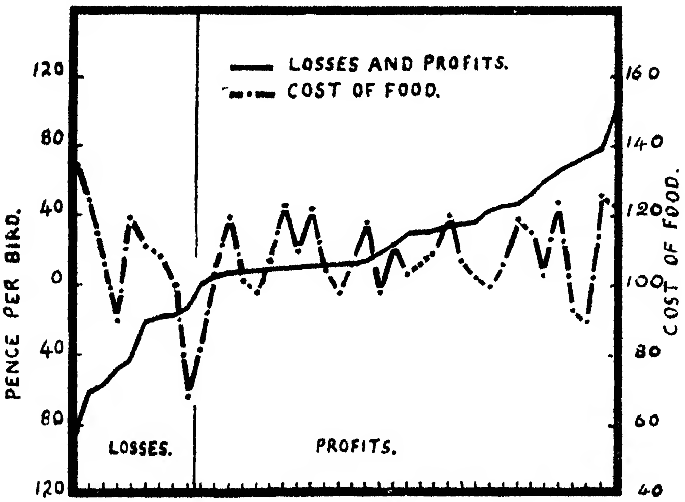
The effect of any increase in the cost of feedingstuffs upon costs of production is direct, the total costs increasing with any increase in the cost of foods. But the effect upon profit is less obvious because the increase in prices of foods may be part of a general price movement or the reactions of individual managers may restrict its influence The records collected in 1935-36 show that the simple relationships between the average costs per cwt of feedingstuffs and profitableness was of a negative character, that is the higher profits tended to be associated with the lower costs of poultry foods. In the following year the simple relationship was positive in character, but in neither year was the relationship significant. While the records fail to indicate the reasons for these opposing results it seems probable that under the favourable economic conditions of 1935-36 some managers may have been too extravagant in the use of the relatively expensive mashes. Last year some farmers were too economical in the use of the higher priced meals and mashes and in a few cases heavy reductions in production occurred and these more than offset the saving in costs of feedingstuffs. The records show that where a consistent but careful feeding policy has been followed over the last three years reasonable profits have been earned.

Most of the enterprises studied in Wales range from 150 to 400 laying birds so that the managers are not often in a position to take advantage of the cheaper rates offered for orders of

two ton lots or more. The differences in the average prices paid for foods by different managers mainly arises from differences in the proportions of the different classes purchased. Nearly all managers now feed meals or mashes to their poultry as well as grain but the proportions range from 20 per cent. mash with 80 per cent. maize to 60 per cent. mash, 10 per cent. wheat and 30 per cent. maize. Apart from one or two cases in which extremely high or extremely low average costs were recorded the variation from farm to farm was about two shillings per cwt. If there has occurred any significant difference in the average cost arising from differences in quality the higher price would tend to be associated with higher profits. Alternatively if farmers are paying different prices for the same product the lower costs of foods would be associated with the higher profits. Figure 1 shows the relationship between costs of food per cwt and profit per bird.

FIGURE 1.

Profits per Bird and Costs of Feedingstuffs per cwt.

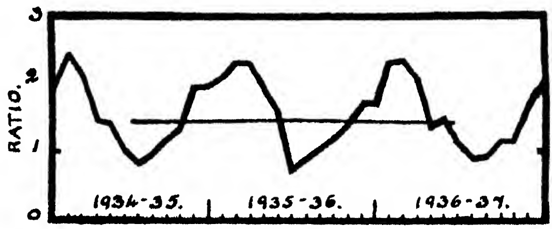


The Figure indicates connections between costs of food per cwt and profits per bird in individual cases where costs of food move towards extreme points as where very high costs are associated with loss and a very low cost with the point between profit and loss. There is also a tendency for wider variations in costs to show themselves amongst enterprises earning the highest profits. But the broad conclusion is that there exists no important degree of general relationship between costs of foods and profitableness which is unchecked by other conditions.

Profits and Prices of Eggs. Under conditions in which costs of feedingstuffs amount to nearly 60 per cent. of the total costs, and returns from eggs to 65 per cent. of total receipts, any changes in the prices of these two items must, in general, affect to an important extent the profitableness of the industry. The collected information from farms in Wales shows that over the last three years there has been very little change in the relative price movements of these two items.

FIGURE 2.

Ratio of Cost of Feedingstuffs to Price of Eggs.



In each of the last four years the value of 120 eggs has been equal to the cost of 1.3 to 1.5 cwt. of feedingstuffs and the following is a summary of the essential data.

Cost of Feedingstuffs and Prices of Eggs.

Year.	*Cost of Feed per cwt.*	*Value of Eggs per 120.*	*Ratio of value of Eggs. to Cost of Foods.*
	s. d.	*s. d.*	
1933-34 ...	8 8	11 5	1.32
1934-35 ...	8 1	11 5	1.41
1935-36 ...	8 3	12 3	1.49
1936-37 ...	9 3	12 11	1.40

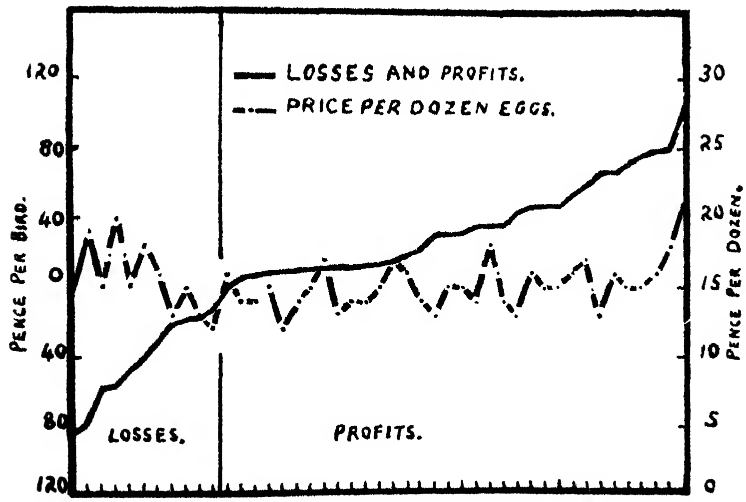
Since 1934-35 the cost of feedingstuffs increased by 14 per cent. and the value of eggs by 18 per cent. These general conclusions lend further support to the suggestion that the industry as a whole has suffered less from the general movements in prices than is commonly supposed.

Turning now to the relationship between the prices received for eggs by groups of managers and the profits earned in their enterprises the general expectation would be a significant positive correlation. The records collected during 1936-37 show yearly

average prices ranging from 1s. 0d. to 1s. 9d. per dozen. Assuming an average yield of 144 eggs per bird these differences in prices would result in differences of up to 9s. 0d. per bird in the returns from eggs. The most common range, however, was from 1s. 3d. to 1s. 5d. per dozen. Part of the higher price received by some farmers must be set against extra costs incurred in marketing and the extra price obtained is not necessarily a measure of the net advantage which these managers had over those receiving the lower prices. The very highest prices were obtained by those managers selling their eggs direct to consumers or to retailers and in a few cases those who sold to consumers incurred costs of marketing which were higher than the extra returns obtained.

Any advantage obtained from selling eggs at higher prices was either of less significance than is commonly supposed or was offset by some other counteracting factor for Figure 3 shows that there was no general tendency for prices of eggs to be positively associated, in any significant manner, with profitableness.

FIGURE 3.
Profits per Bird and Prices of Eggs per dozen.



The Figure shows that the average prices were highest for the enterprises with losses.

Profits and Yield per Bird. A good deal of emphasis is placed upon the importance of improving the quality of birds maintained on general farms. In the absence of any counteracting circumstances an increase in production must have an

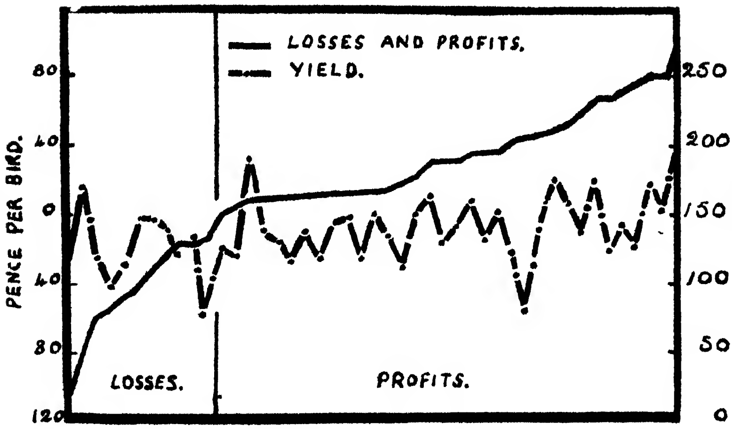
obvious direct effect. The ratio of maintenance to production food requirements becomes less as production increases; or, in other words, as the yield increases the birds convert a larger proportion of the total food consumed into eggs and the quantity and cost of food per dozen eggs should therefore fall. The expectation of improved profitableness arising from increased yields certainly may be placed very high in cases where the average yield is less than 100 eggs per bird but when the flock average yield has passed 12 dozen eggs it is doubtful whether further substantial increases can be obtained with advantage to the managers of flocks kept under farm conditions.

A general feature of flocks giving the higher yields is the substantially better production obtained during the winter months when prices are high. Flocks giving yields below 120 per annum often fail to produce more than 2 per cent. of their annual total (or say 3 eggs) during November. But flocks giving yields of 160 eggs may produce as much as 7 per cent. of the total (or 11 eggs) during November and it follows that these differences in the monthly distribution of production must influence the annual average price obtained, the higher prices being obtained for eggs from flocks giving the higher yields.

The practical results, however, are less simple than the theoretical expectations. The profitableness of egg production from any given flock of birds is dependent upon its capacity for producing eggs in relationship to the quality and class of food consumed. It has already been noted that there was no marked relationship between costs of feedingstuffs and profitableness and the differences in cost of foods per cwt. were due largely to kinds of foods purchased. The results show that both high profits and losses were earned by flocks having good mixed rations and also by those having rations containing a high proportion of whole and cracked maize. It is stated that the "kind of mash fed, or the proportion of grain and mash has less relation to production per bird than have well-bred healthy and well-developed pullets with warm water to drink and regular feeding."[2] But the real mistake is in assuming that good feeding with mashes and grain can be a remedy for poor quality birds or that the production of good quality birds will be independent of the quality of housing and the kind of food provided.

[2] Misner, E. G. Economic Studies of Poultry Farming in New York, VI. Cornell University, Ithica, N.Y.

FIGURE 4.
Profits and Yields per Bird.



Yield per bird is one of the most important factors accounting for differences in profitableness and measurement of the simple relationships indicates that in each of the last two years 25-30 per cent. of variations in profits could be accounted for by differences in yields and the chief conditions which affected them.

Profit and Depreciation per Bird. Very closely associated with yields is the problem of mortality and general depreciation. There is no real purpose in measuring separately the relationship between profits and mortality rates because this is so closely associated with the general costs of stock. Collected records indicate that costs of depreciation per bird are highest for those enterprises having the highest culling and selling-rates, and these have the lower mortality-rates. The higher production obtained from the flocks having the high replacement-rate, however, resulted in the costs of depreciation per dozen eggs being lowest.

In addition to breeding for high production most farmers now introduce a large proportion of pullets into their laying flocks annually in order to maintain production at a maximum. Sales of birds from the laying flocks are influenced by four main considerations :

(*a*) Failure of pullets to give satisfactory performance,

(*b*) Need to dispose of unhealthy stock,

(*c*) Need to dispose of older birds in order to provide accommodation for pullets, and

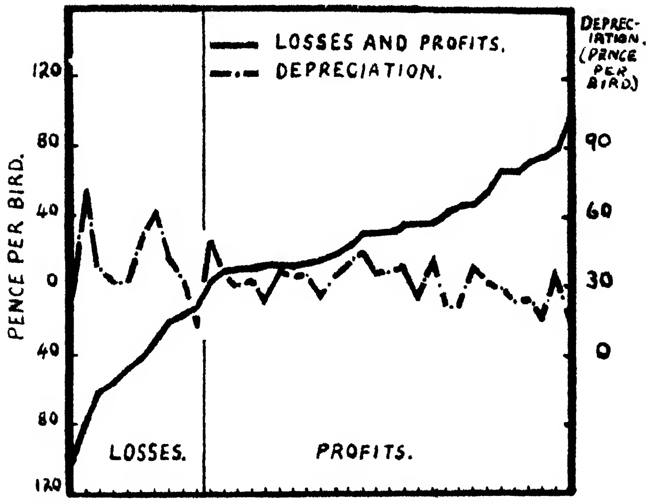
(*d*) Desire to reduce the laying flock to a minimum in the spring when eggs are cheap.

The average price received for birds sold from the laying flocks is about 2s. 0d. each and the records of monthly sales do not show any marked seasonal variation in that price. Assuming that the cost of producing pullets amounts to 5s. 0d. per head a charge of 3s. 0d. must be made against the total eggs produced during their productive life. At the beginning of October the general composition of the laying flock would be 53 per cent. pullets and 47 per cent. hens. During the year 16 per cent. of the birds die while a further 37 per cent. are sold and at the end of a year only 47 per cent. of the original birds remain in the flock. It follows from this that the average productive life of the laying birds is less than 18 months.

Assuming a yield capacity of 144 eggs and a cost per pullet of 5s. 0d., the variations in some conditions are easily displayed. Suppose 100 pullets cost £25 and each lives to complete two years' laying, *i.e.* the very best possible condition, and are then sold for 1s. 0d. each, the stock cost is 4s. 0d. spread over 24 dozen eggs or 2d. per dozen, or if the sale price of hens is 2s. 0d. each, then the stock cost is 1½d. per dozen. This is a necessary minimum cost and as soon as deaths occur or it becomes necessary to cull and sell birds before they have completed two laying seasons, the stock cost increases beyond 1½d. or 2d. per dozen. As deaths increase in importance the need to cull and sell becomes more urgent and the reduction of laying flock not only adds to the stock costs but also to the charges for capital depreciation and labour per bird.

The general circumstances associated with deaths and depreciation are such that a high degree of negative relationship between costs of depreciation and profits might be expected. Unhealthy birds give rise to increased mortality-rates and lower yields and under the worst of circumstances the cost of depreciation may be as high as 6d. per dozen eggs. The influence of the health of birds upon production is very important and one of the contributory reasons for failure to obtain any significant association between profits and some of the causal factors previously considered. Abnormally high cost of depreciation occurred amongst flocks suffering losses and it was lowest for those earning the highest profit.

FIGURE 5.
Profits and Depreciation per Bird.



Deaths of hens in the laying trials tend to follow the heaviest laying period and many are caused by the immediate strains of production. But deaths in commercial flocks are much more evenly scattered over the year; they show less immediate association with the strains of egg production and more general causes than those in the laying trials. During 1936-37 the flocks recorded showed death-rates varying from 4 to 62 per cent., with an average of 22.3 per cent.

Period of Production. The practice of disposing of large numbers of healthy laying birds in the spring because prices of eggs are low is not entirely justified by the information collected. It is a popular belief that poultry are not profitable during the spring, most people failing to take account of the monthly egg production as well as the price obtained. The probability is that flocks giving average yields of less than 100 eggs are only profitable during the four or five months commencing with March. In the case of the better class of birds giving average yields of about 146 eggs, profits are earned during the spring months and may be as important as those earned during the winter. The following summary based upon collected records indicates the relative profitableness of poultry in each month of an accounting year.

These results indicate higher profits during the summer and early autumn when prices of eggs are increasing. If this estimate is justified it follows that mistakes may be made by reducing the

Monthly Costs and Returns.

Month.	*Yield.*	*Price of Eggs each.*	*Total value.*	*Cost per Bird.*	*Margin Profit + Loss —*
	No.	*d.*	*s. d.*	*s. d.*	*s. d.*
October	10	2.06	1 9	1 2	+ 0 7
November	7	2.08	1 2	1 2	—
December	9	1.89	1 5	1 2	+ 0 3
January	10	1.25	1 0	1 2	— 0 2
February	11	1.37	1 3	1 2	+ 0 1
March	16	1.10	1 6	1 2	+ 0 4
April	17	0.89	1 3	1 2	+ 0 1
May	17	0.92	1 4	1 2	+ 0 2
June	14	1.10	1 3	1 2	+ 0 1
July	13	1.46	1 7	1 2	+ 0 5
August	11	1.58	1 5	1 2	+ 0 3
September	11	1.77	1 7	1 2	+ 0 5
Total	146	1.35	16 6	14 0	+ 2 6

number of birds in laying flocks in the spring. Under present methods a serious wastage of housing accommodation occurs and by maintaining the numbers until the autumn the total cost of capital depreciation is charged against a larger number of eggs.

Profit and Size of Laying Flock. It is often suggested that managers of the larger enterprises are able to purchase feeding-stuffs more cheaply, are able to utilise their labour power more efficiently and, finally, that they are often in a better position to sell their produce on contract to hotels and restaurants at higher prices. Variations in prices have already been dealt with and it appears that in Wales the advantage does not always lie with the larger producers.

Any general advantage which the owner of the larger enterprises may have must arise from the better utilisation of capital, equipment and labour. It is commonly suggested that a flock of 800-1,000 laying birds will provide full time employment for one man and the probability is that a flock of 1,200 laying birds is as wasteful of labour as a flock of 400. Few, if any, flocks of 1,200 layers could be managed efficiently by one man each and unless additional part-time employment can be found for the extra labour engaged wastage will result. The manager of a flock of 400 layers may have other interests and the time spent on poultry may be efficiently utilised.

There is some evidence that the capital equipment of larger enterprises tends to be utilised more efficiently; that the ratio of investment in capital equipment to investment in livestock is

lower than in the case of the very smallest enterprises. The advantage of the larger unit is due partly to the greater use that can be made of hatching and rearing equipment and of small tools and utensils. All farmers with flocks ranging from 100 to 400 laying birds would require one incubator and one brooder but the owner of the 400 birds would use these two pieces of equipment, say, six times each year, whereas the other manager would probably use them only once. But these advantages are not significant in themselves and the range of profits and losses is equally wide for large and small enterprises.

Summary.

The influences which determine profitableness in egg production arise (*a*) amongst cost factors, (*b*) amongst other factors. The chief cost factors and their relative weights in the total of costs are—feed, 58; labour, 18; stock costs (deaths and differences between costs and selling values), 13; housing and equipment and miscellaneous items, 10. The chief of the other factors are prices of eggs and what may be called the effective converting capacity of the hen, that is, her power of producing eggs from the feed, housing and other conditions provided. In the prices of eggs themselves there will be four sets of conditions—size and quality of eggs; seasonality of production; location of farm in respect of advantages or disadvantages in selling; and changes in the value of money. These factors, except that of the converting capacity of the hen, are more or less directly measurable within one enterprise and lend themselves to rough comparisons from farm to farm. The converting capacity of the hens is perhaps the dominant factor, but it is not a simple one and its manifestations certainly are not simple. Two flocks may have what appears to be about equal laying capacity of 160 eggs a year or, say, 300 eggs in two years of expected working life, but in one the death-rate is 30 per cent., while in the other the death-rate is 10 per cent. In that case the effective capacity of the first flock will be only about 225 while that of the second will be 274 as compared with the nominal 300, or yearly means of 112 and 137 against the original 150 expected. This assumes equal treatment of birds and that differences in effective yields are due to differences in birds which look or handle the same.

But the effective yield is a reciprocal between the birds themselves and the supplies and conditions provided for them—that is, between the birds and the management. Given two

flocks with exactly the same initial capacity their yields will be different; and this may be due to many causes, but in particular, foods and accessories with foods may be too much, too little, suitable or unsuitable; housing may be suitable or unsuitable, sanitary or unsanitary.

Influences in costs go much further than this. Over the whole range there may be (1) economical or uneconomical purchase and use of feeds according to the initial capacity of the hens, (2) labour attention to hens may be adequate or inadequate in relation to their initial capacity and needs, (3) housing may be suitable or unsuitable, economical or uneconomical, (4) size of flock and lay-out may lead to economical or uneconomical use of labour. Then in the practice of management there will be differences in degrees of efficiency at various points. In one flock feed supply may be wholly appropriate and adequate, but attention may be inadequate and housing poor; while in another flock housing may be good, attention and feeding rather poor; and in still another good feed and good standard of attention will be combined with poor housing.

Taking into account as many as possible of the factors, the high complexity of the determination may be illustrated by giving values to indicate high or low standards for each of four flocks and weighting these by their assumed importance as a determinant of profitableness. Only very rarely are all the factors found to be above or below the normal standard of management.

Illustration of Variations in Efficiency and Compensation.

	Normal Standards.	*Flock.* 1.	*B.*	*C.*	*D.*
Capacity and Stamina of Breeding Flock	100	150	150	150	150
Hatching for Winter Production ..	100	120	90	140	100
Health of Pullets	100	90	140	90	90
Feeding	100	130	90	100	70
Housing	100	100	100	90	90
Attention	100	120	90	110	100
Quality and Grade of Egg	100	120	90	100	100
Size and Layout	100	100	110	90	90
Situation	100	90	160	100	120
Relative Profitableness	100	110	111	102	90

The four owners start with breeding flocks having the same capacity and stamina. In the case of Flock A every factor except situation and health is above standard; in both B and D four of the nine factors and in C three are below standard. Taking account of the relative importance of each of the conditions it is possible to indicate the relative profitableness of each flock. In the case of Flock A the advantage of good feeding, housing and management is offset by poor health and situation. Flock B exhibits all the characteristics of poor management and yet because of the general good health of the birds and the very important advantages of a good situation for disposal of produce, its relative profitableness slightly exceeds that for Flock A. In the case of Flock C we have the combination of poor size and layout, bad housing and health while attention, feeding and quality of eggs are up to standard. Taking account of the relative importance of these sets of conditions it would probably be found that this flock was less profitable than either Flock A or B. The unfavourable position indicated by Flock D arises from general inefficiency. Two of the most important factors are below standard and in the case of feeding this is 80 per cent. below standard. The most favourable factor was only 20 per cent above standard and under such circumstances the relative profitableness will be below standard.

In all collected records these and other sets of combinations of the different standards for the responsible factors will be found It is the direction and the strength of the pull of each of the causal factors combining to determine the direction and strength of the net pull which determine the profitableness of individual enterprises. The amount of control which managers can exercise in their individual capacities over many of these factors is great and by individual and collective action complete control can be instituted. The most urgent need of the industry is the introduction of strict control over the breeding and sale of young stock and sale of hatching eggs, and there is also need for fuller research into poultry diseases. The collected evidence shows that with good healthy stock, good feeding, housing and general management and good marketing facilities reasonable profits can be earned by poultry even at the present high level of costs of foods.

THE EFFECT OF PARTIAL FIELD-DRYING AND ARTIFICIAL DRYING ON THE CHEMICAL COMPOSITION OF GRASS.

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The practice of grass drying is the direct outcome of results obtained in a number of investigations into the chemical composition and nutritive value of young leafy grass cut at varying intervals throughout the grazing season (1), (2), (3), (4).

These investigations, conducted over a series of years in different parts of the country, show that the more often a grass is cut, the richer the product is in crude protein and the lower its content of crude fibre, and in addition, that the percentage of protein in the dry matter of such grass compares favourably with that found in many concentrated foods.

As a result, artificially dried grass has become a commercial product, and to a certain extent, is taking the place of concentrated foods, more particularly in the rations of dairy cows, and when ground into a fine state, in the rations of pigs and poultry.

It is of interest to note that artificially dried grass is the only home-grown food that is sold with a guarantee as to its chemical composition. Further, its appearance on the market has been responsible for the estimation of an additional constituent in the commercial analysis of food stuffs, namely, carotene, the amount present being often guaranteed

As often occurs with the introduction of a new food stuff, a certain amount of dissatisfaction—some not without reason—has been expressed at the results following the introduction of dried grass into the ration of dairy cows. The unfavourable effects are mainly due to errors committed in the process of production, which if not strictly guarded against, result in an inferior product. The most common of these is to allow the grass to become too mature before cutting, which results in the product more closely resembling dried hay than grass (see Table IX).

What is often not realised is that the whole campaign of grass drying has to be carefully thought out and planned; otherwise it is difficult, if not impossible, at certain periods of the growing season to avoid being overwhelmed with grass that is ripe for cutting, but with which it is impossible to cope. To

the person who dries grass for sale, bulk may be all important, but quantity in this respect is always obtained at the expense of quality. Such a product could not be classified as a concentrated food and is little better than a good sample of hay. The grass has been allowed to become too mature and the percentage of protein in it may be as low as 9 per cent.

There is reason to believe that a great deal of the grass cut for drying is wholly unsuited for the purpose, particularly owing to its advanced stage of growth and inferior botanical composition. In the investigations referred to (1), (2), it was shown that from a nutritive point of view, the leafy portion of a grass is far superior to the stem, and that consequently the more leafy the herbage when cut, the higher the percentage of protein in the produce. The advantage of sowing and encouraging the more leafy strains of grasses is well known, and for the purpose of grass drying this is of particular importance, for the produce of such grasses, provided they are cut before becoming too mature, gives the best type of dried grass.

The cost of producing dried grass is influenced by a number of factors, the most important of which are the cost of labour, fuel, power and manures, all of which are subject to variation. Whatever the circumstances affecting some of these, the cost of fuel will depend directly upon the amount of water to be expelled from the grass, and any means of reducing this should be adopted, provided the chemical composition of the finished product is not adversely affected in the process, and that the cost of collecting the grass is not increased.

One method practised is to allow partial drying or wilting of the freshly cut grass in the field. This has its disadvantages and to many of these Roberts (5) has drawn attention. We found at Aberystwyth as a result of adopting this method, that under favourable climatic conditions grass containing 80 per cent. of water lost 20 per cent. of this in 24 hours, and that in 48 hours it lost over 40 per cent. In view of the important bearing of this on the cost of fuel, steps were taken to determine the effect of wilting on the nutritive value of the grass as shown by its chemical composition.

For this purpose, a number of grass samples were partially dried under a variety of experimental and field conditions. All the samples were chemically examined as soon as possible after cutting and at intervals during the period of wilting or drying. In addition to the constituents usually determined, carotene was

determined by the method of Ferguson and Bishop (6), and the HCl-pepsin soluble protein by Wedemeyer's modification of Stutzer's method.

On May 14th, 1937, a quantity of freshly cut grass was spread to dry on wire netting supported on a wooden frame standing three feet above ground. The grass during the whole time was exposed to the prevailing climatic conditions, the one variation from the general practice followed in the field being that the grass did not rest on the ground.

The water content of the grass was determined with as little delay as possible after cutting, and representative samples were withdrawn at intervals extending over twelve days for similar determinations. The drying of each of the grass samples was completed in the laboratory ovens at a temperature of 85° C. and the dry matter thus obtained subjected to chemical examination The following table shows the effect of wilting on the different constituents determined.

TABLE I.

Date of sampling.	*Period of wilting in hours.*	*Percentage of dry matter.*	*Percentage crude protein in dry matter.*	*Carotene in mgms. per 100 grms of dry matter.*
May, 1937.				
14th	0	22	11.0	17
15th	24	43	11.7	18
18th	96	63	11.4	14
26th	288	49	11.6	8

The weather from the 14th to the 18th of May was ideal, being sunny with no rain. On each of the succeeding six days, from the 18th to the 24th, some rain fell, making a total for the period of practically one inch.[1] For the remaining two days there was little sun and no rain. The effect of the dry and wet periods is seen in the percentages of dry matter, for at the end of the four dry days the grass had lost over 50 per cent. of the water it originally contained, while as a result of the rain and the succeeding two dry days it had taken up additional water. From the table it is seen that while the weather remained dry, the effect of wilting on the protein and carotene content was only slight, but the wet weather that followed had a marked effect on the carotene, though the protein content appears to to have been unaffected.

[1] Data obtained at the Welsh Plant Breeding Station.

Similar results were obtained with freshly cut grass laid out to wilt on a flat roof. During the first 36 hours the weather was sunny with no rain and the carotene content fell from 48 to 40 mgms. per 100 gm. dry matter, but after exposure for seven days with one night of heavy rain it fell to 17 mgms. The percentage of crude protein on the other hand showed no significant fall, being 22.9 and 22.5 per cent. at the beginning and end of the period respectively.

These results show that sunlight and rain are important factors influencing the carotene content of cut grass, and in order to investigate their influence further, a quantity of grass was divided into three representative portions. One was placed on the frame already referred to and exposed to the prevailing climatic conditions, the second was spread on the floor of a barn, and the third loosely packed in a jute scrim bag was hung from a beam in the roof of the barn.

Table II gives the dry matter, protein and carotene content of the grass as cut and after wilting under these varying conditions.

TABLE II.

Date of sampling.	*Period of wilting in hours.*	*Percentage of dry matter.*	*Percentage crude protein in the dry matter.*	*Carotene in mgms. per 100 gm. of dry matter.*
1937.				
May 31st	0	21	17.3	45
On Frame				
June 1st	20	44	17.4	40
,, 2nd	44	61	17.3	33
,, 6th	150	60	17.7	15
In Barn				
June 1st	20	34	17.2	40
,, 2nd	44	57	17.6	40
In Jute Scrim Bags				
June 6th.	150	70	17.8	43

The weather for the first 44 hours was dry and sunny; subsequent to this there was little sun and a third of an inch of rain fell before the end of the period. As would be expected, water was lost more rapidly from the grass on the frames than from that in the barn, this being evident from the dry matter content at the end of 44 hours. Due to an unfortunate misunderstanding, the grass in the barn was removed at the end of 44 hours, and consequently it was impossible to complete the comparison.

The influence of sunlight and rain on the carotene content of freshly cut grass is strikingly shown in Table II, for under the conditions of wilting indicated, 66 per cent of the original carotene was ultimately lost. The carotene of the grass on the frame after 44 hours' exposure to dry weather was reduced by approximately 27 per cent., while in the grass exposed to the diffused light in the barn the reduction was only 11.1 per cent. Of all the methods employed, the most efficient for drying and at the same time preserving the carotene was loosely packing the grass in jute scrim bags, the reduction in carotene being to all intents and purposes negligible.

The difference in the percentage of crude protein under these conditions, as in the former cases, was of very little significance. Further evidence of the difference in the carotene content of cut grass wilting in direct sunlight on the one hand, and diffused light on the other is shown in Table III, giving the carotene and protein content of grass wilting in the field fully exposed to sunlight as well as in the shade.

TABLE III.

Date of sampling.	*Period of wilting in hours.*	*Carotene in mgms. per 100 gm. of dry matter.*	*Percentage of crude protein in dry matter.*
1937.			
May 19th ...	0	33	14.2
In Sun.			
May 21st ...	48	21	13.9
May 24th ...	120	16	14.6
In shade.			
May 21st ...	48	27	15.6
May 24th ...	120	24	15.5

The results show that the grass wilting in the sun suffered a reduction in carotene of 51.5 per cent., whereas in that dried in the shade, the reduction was 27.2 per cent.

Where there is a variation in the protein, the reduction is very slight and the increase shown in those samples wilting in the shade might be accounted for by the difficulty of obtaining a representative sample, or to the loss of substances such as carbohydrates.

A fairly complete chemical examination of each sample was made, and the results given in Table IV show that a considerable amount of leaching of the mineral constituents takes place when grass partly dried by wilting is exposed to rain.

TABLE IV.

Period of wilting.	*Silica-free ash.*	*Phosphoric acid* (P_2O_5).	*Lime* (CaO)	*Potash* (K_2O)	*Chlorine* (Cl)
	Percentage.				
Wilted on frame					
Sample as cut	4.22	0.54	0.60	3.02	0.81
After 96 hours wilting ...	3.86	0.52	0.59	2.77	0.80
,, 288 ,,	2.77	0.46	0.56	2.03	0.50
Wilted on flat roof.					
Sample as cut	8.15	1.02	0.74	4.41	1.45
After 36 hours wilting ...	7.68	0.96	0.68	3.99	1.18
,, 168 ,,	5.70	0.91	0.64	2.78	0.69

The sample wilted on the frame is that already referred to in Table I. No rain fell during the first four days, but for the six days following, some rain fell each day; the last two days of the period, however, were dry with little sun. While the weather was dry, the loss in the constituents determined was small, but following the rain the loss was appreciable, especially in the case of potash and chlorine. The sample wilted on the flat roof shows similar losses, the loss of potash and chlorine being again quite appreciable.

The results so far recorded show that the reduction in carotene may be as high as 66 per cent. when grass is exposed to the action of sunlight and rain for a period of twelve days. In practice it is unlikely that grass would be allowed to wilt for more than one or two days where grass drying is the ultimate aim, but in this particular case the object was to ascertain the extent of the changes in protein and carotene over a prolonged period.

To determine the changes occurring under practical conditions in the field, samples were obtained from two sources, one employing a Kaloroil and the other a Billingham drier. Samples of the freshly cut grass were taken in the field and divided into two parts; one was examined as taken in the field and the other enclosed in a wire mesh was passed through the drier and dried along with the bulk of herbage. Similarly, samples of wilted herbage were taken after 24 and 48 hours; these were examined and compared with the corresponding dried grass produced from them.

In Table V the protein and carotene contents of a number of these samples are shown.

TABLE V.

Date of sampling.	Type of drier.	Period of wilting in hours.	Percentage of dry matter.	*In the dry matter.* Percentage of crude protein.	*In the dry matter.* Mgms. carotene in 100 gm. In freshly cut grass	*In the dry matter.* Mgms. carotene in 100 gm. In dried grass.
1937. June 2nd	Billingham.	0	20	11.0	49	28
3rd		24	25	13.9	42	25
4th		48	53	14.9	37	24
June 14th		0	16	13.2	44	29
15th		24	33	12.7	36	27
June 15th		0	22	13.3	33	25
16th		24	36	13.0	33	20
June 16th		0	18	15.4	46	37
17th		24	32	14.8	34	30
June 21st		0	24	10.2	26	15
22nd		24	44	9.5	19	14
23rd		48	56	11.7	18	18
June 24th		0	19	11.8	43	28
25th		24	36	13.1	33	26
June 24th		0	22	11.9	31	12
25th		24	24	14.9	28	13
July 19th		0	17	17.2	44	25
20th		24	27	17.0	30	21
Aug. 23rd		0	19	15.4	41	21
23rd		3	29	15.4	40	20
24th		28	47	14.9	27	20
Aug. 19th	Kaloroil	0	18	18.1	45	26
20th		(*inside heap*) 24	18	18.6	46	22
		(*outside heap*) 24	30	17.9	42	23
		(*spread thinly on field*) 24	41	16.4	36	24

The results given in Table V lead to a number of important conclusions. In the first place it is evident that herbage containing 16 to 24 per cent. of dry matter loses very considerable amounts of water when allowed to wilt for 24 hours, the dry matter content increasing to between 24 and 44 per cent. After

a period of 48 hours the dry matter content, originally about one-fifth of the total weight, may, under favourable conditions, amount to more than half the bulk of the herbage. In other words, to produce one ton of dried grass from the unwilted herbage, 4 tons of water need to be expelled, after 24 hours wilting from 1.3 to 3.2 tons, while after 48 hours only one ton of water requires evaporating. When it is realised that a drier with a reasonable thermal efficiency requires 1 lb. of coke to evaporate 6 lb. of water (7), considerable reduction in drying costs should accrue from successful wilting. Data given by Roberts show that partial field drying resulted in a saving in fuel and power costs of eleven shillings and tenpence per ton of dried grass (5), but as pointed out by this authority, the year 1936 in which the data were collected was particularly unfavourable for successful wilting.

Under practical field conditions the effect of wilting on the carotene content resembles fairly closely that found under the experimental conditions already referred to. The decrease in amount of this constituent present in freshly cut grass was found to vary from 10 to 27 per cent. after 24 hours, and from 24 to 31 per cent. after 48 hours' wilting respectively. As would be expected, the amount lost was largely dependent upon weather conditions.

The important consideration from the practical point of view, however, is not the carotene content of the freshly cut grass, but that of the dried product, and the data given in Table V are of particular significance in this respect. The results show that despite the large difference in the amount of carotene in freshly cut and wilted herbage, this difference is not nearly so pronounced in the dried grass produced from them: for under practical conditions so much carotene is lost in the process of drying that the loss incurred during wilting does not appear to be of great importance. Reference to Table V shows that in the case of the grass cut on the 23rd of August, the carotene content fell from 41 to 27 milligrams per 100 grams dry matter after 28 hours' wilting, and that there was no significant difference in the carotene content of the dried grass produced from the freshly cut herbage and that made from the herbage after wilting for 28 hours.

The loss of carotene in drying varied within wide limits, the average percentage loss in 63 samples being 33. In only two instances was the loss under 10 per cent., and in 59 of the samples

it varied from 10 to 60 per cent. Two samples lost over 60 per cent. of the original carotene, the maximum percentage loss recorded being 64.5.

These results show quite clearly that considerable amounts of carotene are lost both during the process of artificial drying and partial field drying. However, the data suggest that the carotene content of the final dried product is more or less the same whether wilting is practised or not, for it appears that during drying, more carotene is lost from freshly cut than from wilted herbage, this loss frequently amounting to 50 per cent.

This effect of drying on the carotene content is further illustrated in Table VI.

TABLE VI.

Type of herbage.	*Carotene in milligrams per 100 gms. dry matter.*		
	Freshly-cut grass.	*Dried grass.*	*Oven-dried grass.*
Cocksfoot S. 26	32	26	6
Cocksfoot S. 37	32	26	10
Timothy S. 48	31	23	15
Timothy S. 51	32	23	9
Perennial rye-grass S. 101	29	28	12
Mixed herbage	41	21	14
Mixed herbage	40	20	20
Mixed herbage	27	20	7
Mixed herbage	29	25	13
Mixed herbage	37	17	9
Mixed herbage	45	26	14
Mixed herbage	36	24	19
Mixed herbage	42	23	20
Mixed herbage	46	22	11

The results shown in Table VI were obtained with a Kaloroil drier at Pwllpeiran—the Welsh Plant Breeding Station Cahn Hill Improvement Centre—where the in-going air reached temperatures between 150° and 180° C. and the out-let air 135° to 140° C., the actual drying taking about 20 minutes. The oven-dried grass on the other hand was chopped and spread on trays and heated for 24 hours at a temperature of approximately 85° C.

The effect of drying on the carotene content is very striking. Decreases up to 50 per cent. are seen to accompany the rapid drying of grass, the average being 36 per cent.; while during prolonged drying in the oven, an average of 64 per cent. was lost. From the point of view of carotene preservation, drying at

relatively high temperatures appears to be a much more efficient method than prolonged drying at low temperatures.

In the preliminary experimental work with comparatively small samples of grass no significant difference was found in the crude protein content of the grass after wilting for long periods (Tables I and II). Similar results were obtained when wilting took place in the field, though wider variations are met with in the results shown in Table V, probably due to the difficulty of obtaining representative samples.

It would appear from these results that from the purely chemical standpoint, dried grass produced from wilted herbage is generally as rich in protein and carotene as that made from freshly cut grass. It should be remembered, however, that fermentation which occurs in freshly cut grass must result in losses of dry matter during the period of wilting, and that such losses are much greater when the material is subjected to heavy rain. That wilting has undoubted advantages to the grass drier is obvious, but these are liable to be nullified by unfavourable climatic conditions.

TABLE VII.

Type of herbage.	*Percentage crude protein in dry matter.*			*Percentage digestibility of the crude protein (HCl-pepsin solubility).*		
	Freshly-cut grass.	*Dried grass.*	*Oven-dried grass.*	*Freshly-cut grass.*	*Dried grass.*	*Oven-dried grass.*
Cocksfoot S. 26 ..	14.3	13.2	14.0	57	81	67
Cocksfoot S. 37 ...	14.5	13.4	14.7	59	79	71
Timothy S. 48 ...	14.8	14.1	15.1	59	77	75
Timothy S. 51 .	16.6	14.5	16.5	63	79	69
Perennial rye-grass S. 101	15.1	14.2	15.2	63	81	75
Mixed herbage ...	16.8	15.4	15.5	69	77	73
Mixed herbage ...	18.5	15.4	17.9	68	72	76
Mixed herbage ..	16.1	13.9	16.6	63	74	68
Mixed herbage ...	14.9	15.5	14.7	55	79	71
Mixed herbage ...	20.1	18.4	19.0	74	79	71
Mixed herbage ...	18.8	18.1	18.0	74	81	73

The foregoing discussion has been mainly concerned with the effect of wilting on the carotene and protein content of grass, as well as the loss of carotene during the process of drying. A matter of equal importance from the nutritional point of view is the effect of drying on the protein content and its digestibility. The results of a number of determinations made to investigate

this are summarised in Table VII. In addition this table illustrates the influence of rapid drying compared with slow oven-drying on the total and HCl-pepsin soluble protein.

The results show that the percentage of crude protein in the freshly cut and oven-dried grass is very similar, whereas with one exception the grass dried in the drier contains a lower percentage of this constituent. It would, therefore, appear that rapid drying at a relatively high temperature lowers the protein content of the original herbage to a greater extent than does prolonged drying at lower temperatures in an oven. The average difference in the protein content of the freshly cut and dried grass is 1.3 per cent , which represents a percentage decrease of approximately 8 per cent.

The tendency for herbage to lose more of its crude protein when dried in a drier is again indicated on comparing the crude protein content of grass dried by each method. Thus of 100 samples, portions of each of which were dried in a drier and an oven, the percentage of crude protein was higher in the oven-dried material in eighty-three instances.

The results showing the influence of drying on the digestibility of the crude protein should be interpreted with caution, for it would seem from these results that the protein of freshly cut grass is the least digestible, whereas the figures in Table VII show that drying for 12 hours in an oven certainly lowers the HCl-pepsin solubility when compared with rapid drying. The above determinations, it should be pointed out, were carried out on the freshly cut grass, chopped into lengths of $\frac{1}{8}$ to $\frac{1}{4}$ of an inch, while the dried grass was ground to pass a 1/64th inch sieve of a Christy and Norris mill. It has been shown that fineness of division has a considerable effect on the digestibility of grass as determined by this method (8). The pure species referred to in Table VI were again cut later in the season, chopped as before, and suitable weights placed in a mortar together with silver sand rendered nitrogen-free The grass and sand were then vigorously ground together, the mixture washed into a beaker and the digestibility determined in the usual manner. For purposes of comparison, determinations were also made with the chopped grass not pulverised with sand. The results obtained are given in Table VIII.

TABLE VIII.

Type of herbage.	*Percentage crude protein in dry matter.*			*Percentage HCl-pepsin solubility of the crude protein*			
	Freshly-cut grass.	*Dried grass.*	*Oven-dried grass.*	*Chopped freshly-cut grass.*	*Pulverised freshly-cut grass.*	*Dried grass.*	*Oven-dried grass.*
Cocksfoot S. 26	18.6	17.7	18.7	56	72	82	78
Cocksfoot S. 37	18.8	17.4	18.4	55	71	81	75
Timothy S. 48 ..	18.1	16.9	17.3	64	76	81	77
Timothy S. 51 ...	17.7	16.2	16.8	62	76	79	73
Perennial rye-grass S. 101 ...	15.7	14.8	15.1	62	78	82	—

The results shown in Table VIII confirm those given in Table VII with regard to the decrease in protein content caused by rapid drying. The main purpose of Table VIII, however, is to show that the HCl-pepsin solubility of the protein depends to a very large extent on the physical condition of the freshly-cut grass; for in the case of the pulverised material the protein digestibility is from 12 to 19 per cent. higher than in the grass chopped into lengths of from $\frac{1}{8}$ to $\frac{1}{4}$ inch. It is reasonable to suppose that more efficient pulverisation would increase the digestibility still further but without more complete information on this point there is no justification for comparing these results with those for the finely ground dried grass. It may, however, be said that the protein of dried grass is highly soluble in the solution of HCl-pepsin used for determining protein digestibility, and that drying in an oven at 85° C. for 24 hours has a deleterious effect on its digestibility.

It is a well recognised fact that high yields of grass are generally obtained at the expense of quality, and that although such a system of management yields a higher total of crude protein from a given area, the chemical composition of the produce cannot compare with that of the smaller bulk from a similar area cut at a suitable stage of growth for the production of dried grass of high quality. This is illustrated in Table IX, where the yield and chemical composition of grass cut from the same area at different dates are given. For purposes of comparison, a sample of hay from the same field is included, which was put through the drier after wilting for five days, though the original intention was to harvest it in the usual way.

TABLE IX.

Date of cutting.	Yield of dried grass in cwt. per acre.	Percentage in dry matter.							
		Ether extract.	Crude protein.	Crude fibre.	Silica-free ash.	Phosphoric acid (P_2O_5).	Lime (CaO).	Potash (K_2O).	Chlorine (Cl).
7/6/37	20	3.92	10.8	28.2	5.15	0.67	0.93	3.18	0.81
20/7/37	5	6.58	17.2	20.9	8.40	0.76	2.42	3.18	0.60
14/6/37	47¾ (hay)	3.30	11.6	31.9	5.98	0.66	0.71	2.84	1.12

The cut taken on the 7th June represents the growth from May 3rd, 1937, when the previous cut was taken—a period of five weeks. The herbage was stemmy and the yield of dried grass per acre was 20 cwt., the produce both in appearance and chemical composition more closely resembling hay than dried grass. From the same area cut on the 20th July—that is after a period of six weeks—the produce as dried grass was but 5 cwt. Reference to Table IX, however, shows that the latter contained over 17 per cent. of crude protein, whereas the more bulky product contained only 10.8 per cent., slightly less than the hay cut on June 14th. When allowance is made for moisture, the grass and hay dried on June 7th, July 20th and June 14th, yielded 2.0, 0.8 and 5.2 cwt. of crude protein per acre respectively. The temptation to sacrifice quality for bulk when dried grass is produced for sale is readily seen from the above figures. It cannot be too strongly emphasised, however, that the bulky product is nothing more than good hay and should not be designated "dried grass" if by such a product one means a foodstuff of the nature of a concentrate. In addition to the higher protein content of the less bulky product, it has all the characteristics of younger grass, *e.g.*, a higher ether extract and phosphoric acid content and a lower percentage of fibre. It is evident from these results that there is no hard and fast rule regarding the time which should elapse between successive cutting of herbage for drying. As in the case of rotational grazing, so in cutting grass for drying, the management must be guided by the stage of growth in order to obtain the best results. As suggested by Cheveley, "it is better to make into silage the most forward fields, or to let them go for early hay, and continue to dry the youngest grass available." (7).

In our work with dried grass, we have unfortunately had ample evidence of the inferior nature of the material produced as a result of cutting when too mature. Thus 69 samples of dried grass were examined in 1937, all representing the product dried under practical farm conditions, and it is of interest to see how near these approach " best quality " dried grass in protein content. Cheveley (7) for rationing purposes classifies dried grass into the following groups :—

Dried grass.	*Best quality.*	*Medium quality.*	*" Super hay."*
Percentage of crude protein ...	18 or over	15	12

Of the 69 samples analysed only nine contained over 18 per cent. of crude protein, the highest and lowest protein contents found being 21.9 and 9.5 per cent. respectively.

In Table X these 69 samples are classified on the basis of their protein content.

TABLE X.

Percentage of crude protein.	*Number of samples.*	*Expressed as percentage of total.*
18 or over	9	13
15 to 18	25	36
12 to 15	28	41
Under 12	7	10

The above classification, it should be pointed out, is based on the percentage of crude protein in the dry matter and a less favourable result would be obtained if this had been expressed on the dried grass as sold, containing as it does 2 to 10 per cent. of moisture.

It is very evident from the above results that a great deal more attention must be given to the management of grassland set aside for grass drying, if the produce is to compare with concentrated foods. Leafy strains of grasses should be grown and cut before becoming too mature, thus giving a product rich in both crude protein and carotene. In conclusion it is of interest to consider the relationship which exists between the amounts of these constituents in grass of this character as well as in more mature grass.

TABLE XI.

The Protein and Carotene content of grass.

Percentage crude protein in dried grass.	*Mgms. carotene per 100 gm. dry matter.*	
	Freshly cut grass.	*Dried grass.*
22.9	63	52
22.6	60	44
21.4	46	24
20.2	55	42
18.1	45	26
16.7	46	28
15.6	43	24
14.0	35	21
18.0	33	20
11.8	36	19
10.2	26	15
9.5	19	14

The results given in Table XI are typical of those obtained in this investigation, and suggest that a fairly close positive correlation exists between the protein and carotene content of grass. That this is so was also suggested by statistical analysis of data giving the amount of these constituents in 57 samples. The coefficient of correlation (r) existing between the protein content of dried grass and carotene in freshly cut grass was $+0.76 \pm 0.06$; and between the protein and carotene of dried grass $+0.68 \pm 0.07$. It is interesting to note that a higher correlation exists in the former case, the lower figure obtained in the latter being probably due to the varying amounts of carotene destroyed in drying the different samples. A somewhat higher correlation between the protein and carotene content of dried grass was obtained at Jealott's Hill (9).

Summary and Conclusions.

This paper gives the results of an investigation undertaken to determine the influence of wilting and artificial drying on the chemical composition of grass. It should be pointed out that the following conclusions are based mainly on one year's work carried out in 1937.

(1) It was found that partial field drying or wilting for prolonged periods under unfavourable climatic conditions may destroy as much as 66 per cent. of the original carotene.

(2) Much larger amounts of carotene are lost when herbage is fully exposed to sunlight than when wilting takes place in the shade. Rain was found to accentuate this loss of carotene still further.

(3) No appreciable amounts of carotene were lost when grass was allowed to dry in jute scrim bags.

(4) Herbage allowed to wilt under practical field conditions lost from 10 to 27 per cent. of its carotene after 24 hours, and 24 to 31 per cent. after 48 hours.

(5) That under favourable climatic conditions wilting can effect an appreciable reduction in the cost of artificial drying is shown by the fact that grass under these circumstances lost over 30 per cent. of its original water content. This advantage, however, may be completely annulled by rain.

(6) Wilting under both experimental and field conditions appeared to have little effect on the percentage protein present in the dry matter.

(7) Artificial drying in two types of mechanical driers was found to effect decreases in the carotene content varying within wide limits, the average being 33 per cent.

(8) Despite the large amounts of carotene lost during wilting, the carotene content of the dried produce appeared to be more or less the same whether wilting had been practised or not.

(9) Prolonged drying at lower temperatures was found to be more destructive of carotene than the higher temperatures employed for shorter periods in mechanical driers.

(10) Rapid drying in a Kaloroil drier appeared to reduce the protein content of fresh grass, whereas the prolonged drying in the laboratory ovens had little effect on this constituent.

(11) The protein of grass dried in mechanical driers was found to have a much higher HCl-pepsin solubility than that dried at lower temperatures for longer intervals in the laboratory ovens. Sufficient evidence was not obtained to show whether the protein of freshly cut grass suffered in digestibility as a result of drying.

(12) Data are given which show that the HCl-pepsin solubility of the protein in freshly cut grass is largely dependent upon the state of division of the material digested.

(13) Ample evidence was obtained during the investigation confirming previous work which showed that bulk of grass is always obtained at the expense of quality.

(14) Our results very definitely indicate that before mechanical grass drying becomes a part of ordinary farm practice, a great deal of research work has yet to be carried out if the best results are to be obtained from dried grass

(15) Statistical analysis of results for 57 samples suggests

that a fairly close positive correlation exists between the protein content of dried grass and the carotene content of the freshly cut and dried herbage.

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PASTURE IMPROVEMENT AND THE ERADICATION OF BRACKEN AND RUSHES.

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Probably the greatest problem confronting the hill farmer when he plans out a pasture improvement programme is bracken infestation. He finds that his most amenable slopes of hill land are densely covered with bracken. During the last three or four decades there has been a tremendous increase of bracken infestation on hill land due to two factors, namely, the resting of the plough and the diminution in the numbers of cattle grazing on hill pastures.

It is a general belief that land which is densely covered with bracken is capable of producing good crops and pastures. It used to be said in Wales that land which would grow bracken could be valued in gold, land where gorse and furze grew in silver, and heather-covered land in copper.

Numerous experiments have been carried out to test the efficacy of various chemicals, and whilst sulphuric acid, sodium chlorate and other plant poisons, even in fairly dilute solutions, will kill the bracken fronds, fresh growth starts almost immediately. The two most efficient chemical bracken eradicators so far tried have been calcium chlorate and sodium chlorate. These two chemicals, if applied evenly at the rate of 2 cwt. per acre in powder form, will completely kill all vegetative growth, and if applied during Fewruary or March, even to land very heavily infested with bracken, hardly any growth will take place on that plot for a very long time. The writer applied these two chemicals to heavily infested bracken areas in 1931 and even now very little bracken has come back. There is also one great advantage with this method, namely, that if the dead, dry herbage is burnt in June one has a seed-bed ready made for sowing grass and clover seed. If these chemicals could be bought at about 5/- per cwt. it would probably be the most economical method of bracken eradication and preparation for pasture improvement. Unfortunately, the price is now nearly 35/- per cwt.

The other method of bracken eradication is to cut twice a year, during the latter part of June and the latter part of August, or, if only one cutting is possible, in the middle of July.

It is probably true to say that if bracken infested land is ploughed fairly deeply, half the battle of bracken eradication is won.

When the Cahn Hill Improvement Scheme was established, some members of the Committee were desirous that a demonstration should be carried out to show what could be done to improve a block of hill land with horse labour only. Field No. 11, being fairly near the homestead, was chosen for the purpose.

The field under review is a block of enclosed hill land with bracken growing breast high and at that time was to all intents and purposes nearly useless for grazing. The pasture was composed of Yorkshire fog, a little bent and no wild white clover. Its greatest economic value was as a holding paddock overnight for sheep on their way to the mountain.

During the winter of 1933-1934 this block was ploughed.

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The flatter portions were ploughed with a two horse team drawing a single furrow plough. The steeper portions were ploughed with a three horse team drawing a two furrow plough, ploughing one way and returning up the slope empty. As a matter of fact, the slopes were so steep that it was a stiff task for three horses to pull the empty plough up the hill.

The field was not sown until the latter part of May, 1934, in order that the first crop of bracken fronds could be crushed during the process of harrowing. The following seeds mixture was used together with 3 lb. rape and 2 lb. turnips per acre as a nurse.

Wild white clover dressings	8 lb.	per acre.
Perennial rye-grass	20 ,,	
Cocksfoot	10 ,,	
Crested dogstail	6 ,,	

At the time of seeding the field was dressed with 6 cwt. Basic Slag and 1 cwt. Nitro Chalk per acre.

Early in August, 1934, 106 store lambs were turned on to the rape and turnips for fattening. These lambs made a total live weight increase of 658 lb., equal to 94 lb. per acre.

As soon as the lambs were taken off the field, the bracken was cut,—with a mowing machine on the flatter portions and with a scythe on the steeper slopes. During the subsequent years, the policy has been to use this paddock as a pasture for sheep during the winter months and as a night pasture for the dairy herd during the summer. It is very convenient for the latter purpose as the cowman's cottage is close-by.

The bracken was cut twice during 1935, twice during 1936 and once only in 1937. No actual counts of bracken have been taken, but it would be safe to say that the bracken content of this pasture has been reduced to a negligible quantity.

Other experiments have been carried out on the eradication of bracken, as for example, cutting twice a year after ploughing and cutting twice a year without the initial ploughing. The correct period of cutting, say the middle of June and the middle of August in the first instance, tends to become a few days later every year as the bracken weakens.

The most successful experiment on the eradication of bracken has been the one described above and the most important points may be summarised as follows :—

1. Initial ploughing is of considerable help to get the bracken under control.
2. Cutting twice a year for the first three years and once the following years.
3. The grazing of cattle during the summer months.

A combination of the above three factors has converted an area so heavily infested with bracken as to be practically worthless for grazing into a good pasture.

It is too soon to say for how many years the sparse bracken population will have to be cut once a year in order to eradicate it completely, but it must be emphasised that once bracken eradication is commenced, it is essential for success to carry on unremittingly year after year without a break. If cutting be omitted one year, the bracken comes up the following year with a great deal more vigour. Some people hold that cutting once a year, in July, is nearly as good as cutting twice a year. It is certainly better to cut once a year regularly than to cut two or three times one year and then miss the next year. The work must be carried out systematically.

The harrowing of the young shoots as they come through the soil is also advocated by some people. This has been tried, but continual cutting in the young stage does not seem to have nearly as good an effect as cutting later in the season.

For reasons stated previously, the grazing system adopted for this field was as follows,—heavy intermittent grazing with sheep during the winter and spring months with fairly long rest periods, followed by another rest period in early summer and grazing with cattle only during the summer months—mostly night grazing. In stating this fact, it ought to be explained also that the day paddock for the cattle was the rush-infested field which is also being improved.

It is difficult to estimate the stock carrying capacity of this pasture before it was improved. Owing to the very heavy bracken infestation it was practically useless in summer for grazing and again in winter, owing to the dead bracken covering the ground, it was practically useless for stock. A fair estimate of its stock carrying capacity in this state would be less than one store ewe and one store lamb per acre per annum. The average figures for the grazing obtained for the past three years on the improved swards with the bracken diminishing is as follows. For the winter months, the average stock carrying capacity has been 2.6 sheep per acre for the full possible grazing period and during the summer months the average for the three years is equivalent to 3.6 sheep per acre for the maximum possible grazing period. It ought to be explained here that owing to having to use the cattle to keep down a new sward the grazing for the summer of 1937 is abnormally low and the block was rested longer than usual in order to increase the winter stock carrying capacity.

To get the maximum grazing results from an improved sward it is beneficial to give two rest periods, one in early summer and one in early autumn, especially if the pastures are to be grazed hard by sheep during the winter months. It should also be emphasised that every pasture should be grazed bare or mown over at least once during the summer months.

From observations made of land ploughed the same year and sown with a similar seeds mixture but not grazed with cattle, the diminution of bracken has been less pronounced.

When the Cahn Hill Improvement Scheme took over the present lands, the bottom part of a field called Rhos-y-popty, which is approximately sixteen acres in extent, was infested with rushes. These rushes, when mown in July, 1933, provided a good deal of litter for the stock during the following winter. A second crop was cut in September, 1933, and again collected. The rushes were again mown during a period of hard frost in January, 1934, and they have been mown twice a year ever since in late June and in September.

This field was reclaimed bogland, probably reclaimed in the time of Thomas Johnes early in the nineteenth century, and it is intersected at short intervals with old fashioned stone drains. The peat has shrunk so much in some places that the old stone drains are now literally on the surface. Some of the oldest inhabitants of the district can remember good crops of potatoes and corn growing on this field.

The original herbage was composed mostly of bentgrass, Yorkshire fog, sheeps' fescue, *Nardus*, *Luzula*, *Juncus*, with some *Molinia* in places.

During the winter of 1933-1934 the whole area was drastically harrowed with New Zealand harrows. One half of the field received a dressing of basic slag and the other half, which was practically pure peat, a dressing of gafsa phosphate at the rate of 6 cwt. per acre. During May, 1934, the whole area was sown with cleanings of wild white clover and perennial rye-grass. On the drier and less peaty slopes, the seeds, especially the wild white clover, took well and a tremendous improvement was noticeable even during the first year. The take of the seeds on the upper part was not nearly as good and whilst fairly big areas contain a high percentage of wild white clover, there are areas which show very little improvement.

On the whole, the stock carrying capacity of this field has been tremendously increased. Its greatest use previously was as a day pasture for the dairy cattle during June and July. During the last four years this field has carried during the summer

months about eight horses and ponies and about nine or ten cows during the day time.

It has also during parts of the winter carried a very heavy stocking of sheep. Being practically surrounded by woods, it is one of the most sheltered fields on the farm and during rough weather sheep are brought down into this field from the more exposed areas.

The field received its second dressing of gafsa phosphate during the winter of 1936-1937. Its stock carrying capacity has been greatly increased and the rush infestation has been reduced to an almost negligible quantity. The amount of rushes present now is not sufficient to hinder or shade the growth of the better grasses and clovers. Cutting twice a year is being continued in order to eradicate them completely.

The stocking of this field during the summer months, especially as regards horses, is such as to keep the pasture very bare, as a matter of fact, too bare to do stock well, but this method increases the wild white clover content of the pasture and helps to keep the rushes in check.

The treatment of this paddock indicates that even heavily infested rush land devoid of wild white clover and of little grazing value, can by the above methods be improved so as to produce a fairly good pasture for horses and cattle and that the rushes can be so reduced by continual cutting and hard grazing as to detract very little from the grazing value of the field.

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THE COMPOSITION OF NATURAL HILL PASTURES UNDER CONTROLLED AND FREE GRAZING, CUTTING AND MANURING.

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An experiment designed to provide data on the palatability, yield and composition of natural hill swards with and without the application of fertilizers was commenced at two hill farms in the Aberystwyth area in 1930, reports of which have been published (1, 2 and 3). The experiment has been continued with the same grazing and manurial treatments for the past seven years as it was found that marked botanical changes were taking place. The last paper (3) dealt with the botanical aspects up to the summer of 1934, and the present one is on the data provided by the recent years and brings the evidence up to date.

The Experiment (E.117).

Three types of hill swards were investigated :

1. An open hill fescue-*Agrostis* pasture (Llety fescue).
2. An open hill *Molinia* pasture (Llety *Molinia*).
3. An enclosed hill fescue-*Agrostis* pasture (Bwlchrosser).

The first two pastures were at an exposed situation of 900 ft. elevation, the soil being a dry peat and a peat respectively. The enclosed hill pasture was at an elevation of 850 ft., but was situated in a much more sheltered position and on a light loam soil.

The trial consisted of five fenced and unfenced 1/100th acre plots at each centre. These plots were treated as follows :

1. Lime at the rate of 2 tons per acre of calcium carbonate = plot Ca.
2. Superphosphate at the rate of 4 cwt. per acre = plot P.
3. Superphosphate as above, with the addition of kainit and sulphate of ammonia at 4 cwt. and 1 cwt. per acre respectively = plot PKN.
4. As Plot 3, but with the addition of lime at the above rate = plot CaPKN.
5. A control plot, grazed but not manured with the artificial fertilizers.

The open series of plots was situated at a short distance from the fenced series at each centre, but they were not adjacent.

In 1931 additional fenced CaPKN and control plots were added to each of the Llety centres to obtain hay and aftermath data.

The initial application of lime and manures was made in the spring of 1930. The plots subsequently received each spring superphosphate, kainit and sulphate of ammonia in similar quantities to the above, while additional applications of sulphate of ammonia at ½ cwt. per acre were given to the PKN and CaPKN plots after each monthly grazing. Lime at the rate mentioned above was again applied to the Ca and CaPKN plots in the spring of 1935.

The fenced plots were grazed monthly, the commencing date for each year being the first of May. Six grazings were made per season. For the first four years of the trial when yield data were obtained, sheep were taken to the plots from the Welsh Plant Breeding Station, but subsequently the sheep of the hill farms have been used.

A brief account of the 1934 results.

The comparison made in 1934 between the botanical composition of the fenced and open plots showed that the two methods of grazing had brought about differences in the herbage. Fine-leaved fescue and bent (*Agrostis* spp.) formed the bulk of the herbage at the Bwlchrosser and Llety fescue centres, the original analysis in 1930 showed that fescue comprised 48½ per cent. of the tillers and bent 46 per cent. at Bwlchrosser, while at Llety the fescue was 59 and the bent 31 per cent. At the more exposed and less naturally fertile Llety centre bent had greatly increased over fescue in the fenced and manured plots by 1934. In the open plots the opposite was the case. Much wild white clover had developed in the open CaPKN and P plots at Bwlchrosser, while the two PKN plots were the only ones without this species. More miscellaneous species occurred in the herbage of the control plots than in that of the Ca and P plots, while that of CaPKN and PKN had least of all. The swards in the open plots were denser than the fenced at both centres. There was a far greater proportion of bent to fescue on the manured plot cut for hay and aftermath compared with the control cut plot at the Llety fescue centre.

At the Llety *Molinia* centre there was much more *Molinia* (flying bent) in the herbage of the open plots than in the enclosed grazed plots. The amounts of this species in the fenced CaPKN

and PKN plots were negligible, and bent exceeded fescue in these two plots in which the greatest botanical change took place. There was more *Nardus stricta* (moor mat-grass) in the open plots, with the exception of the Ca ones, and the amounts of this grass in the herbage of the control plots were exceptionally large. The larger proportions of the high tillering fescue and bent in the fenced plots resulted in a greater density of herbage compared with the open plots. There was less *Molinia* and more bent to fescue in the herbage of the cut manured plot than in the control plot.

Results of the present experiment.

BWLCHROSSER.

The data from Bwlchrosser are given in Table I. The herbage in the fenced CaPKN plot shows stationary relationships between fescue and bent, with fescue dominant. This fescue was fine-leaved red fescue. In the open plot the fescue and bent were more equal for 1935 and 1936. In 1937 there was a decrease in the proportion of bent and a very marked increase in wild white clover. Smooth-stalked meadow grass was an important ingredient in the fenced plot, and had increased in the open plot by 1937. Wild white clover, on the other hand, was directly opposite in being only present in small amounts in the fenced plot. The fenced PKN plot consisted chiefly of bent, but by 1937 a more mixed herbage resulted with more fescue and an increase of smooth-stalked meadow grass In the open PKN plot fescue and bent were more balanced, but this plot is in marked contrast to the open CaPKN plot in having extremely little clover. One of the greatest changes occurred in the herbage of the fenced Ca plot. Smooth-stalked meadow grass increased from approximately one-third of the total tillers in 1935 to two-thirds by 1937. The fescue and bent were thus reduced to small proportions. In contrast, the open Ca plot had only 5 per cent. of smooth-stalked meadow grass by 1937, but there was more white clover present each year than in the fenced plot. There were, however, considerable amounts of *Carex*, ribgrass, buttercup and pearlwort in the herbage of the open Ca plot. In the fenced P plot fescue and bent were in fairly equal amounts, but in 1937 bent decreased and there was an increase of sweet vernal grass. Bent was dominant each year in the P open plot, and there was considerably more clover present than in the fenced plot, even exceeding the open CaPKN plot in the later years. The herbage in the control plots differed chiefly from that of the others in having no rough and smooth-stalked meadow grass or Yorkshire fog, but greater proportions of the grasses natural to

TABLE I.—The composition of the herbage at the Bwlchrosser centre for the years 1935-7 based on a percentage tiller estimation.

Year and Plot.	Position.	Fine-leaved fescue.	Bent (Agrostis spp.).	Rough-stalked meadow grass.	Smooth-stalked meadow grass.	Yorkshire fog.	Other grasses.	Wild white clover.	Bird's-foot trefoil.	Miscellaneous spp. (1)	Miscellaneous spp. (2)	No. of tillers per 6in. x 6in.	Per cent. bare ground.
1935.													
CaPKN ...	Fenced ...	58	11½	—	30	—	—	½	—	—	—	420	7
	Open ...	45	42	—	1	½	T	11	—	T	½	675	2
PKN ...	Fenced ...	2½	83	—	10	4½	—	—	—	—	—	451	8
	Open ...	39	47½	—	6	6½	1	—	—	T	—	687	3
Ca ...	Fenced ...	20	33	—	37	1	T	6	—	½	2½	368	8½
	Open ...	49	34½	—	T	—	1½	11½	T	1½	2	531	10½
P ...	Fenced ...	40½	52	—	—	1½	—	5	—	½	½	585	4
	Open ...	27	61	—	—	—	1	8½	—	1½	1	687	T
Control ...	Fenced ...	43	53	—	—	—	½	T	—	3	½	489	3½
	Open ...	17½	44½	—	—	—	3½	½	½	2½	1	690	—
1936.													
CaPKN ...	Fenced ...	61	17	—	20½	—	—	1½	—	—	—	470	2½
	Open ...	47	31½	—	T	T	T	20½	—	½	½	608	—
PKN ...	Fenced ...	8	78½	—	13½	T	—	—	—	—	—	437	1
	Open ...	46½	46½	1	3	T	½	1	—	1½	—	489	4
Ca ...	Fenced ...	31	13	1	49	½	—	2½	T	½	2½	386	½
	Open ...	19½	26½	—	1	1	4	12½	1	1½	3	489	3
P ...	Fenced ...	45	49½	—	½	—	—	3	—	1	1	450	1
	Open ...	16½	55½	—	—	½	2	21½	2	1½	½	555	½
Control ...	Fenced ...	30½	64	—	—	—	1½	T	—	2½	1½	439	½
	Open ...	37	50½	—	—	—	4½	2	T	5	1	387	—
1937.													
CaPKN ...	Fenced ...	52½	9	6½	27	3½	—	½	—	T	—	315	7½
	Open ...	47	23½	—	7½	1	½	19	—	1	½	402	4½
PKN ...	Fenced ...	23	52½	4½	16	4	—	—	—	T	—	368	4
	Open ...	45	49	—	2½	T	½	1	—	2	—	427	9
Ca ...	Fenced ...	15½	12½	1	63	3	2½	1	—	1	½	302	8
	Open ...	37½	11½	3	5	4½	5	8	½	10½	14½	401	2½
P ...	Fenced ...	50	35	2	—	2	9½	1	—	½	T	366	1
	Open ...	11½	58½	T	½	T	T	19½	3	1½	5½	478	—
Control ...	Fenced ...	52½	38½	—	—	—	8	T	—	6	T	386	2
	Open ...	22½	44½	—	—	—	13½	½	1	6	1	393	—

Other grasses = Heath grass (*Triodia decumbens*) and sweet vernal. Miscellaneous species (1) = *Carex* spp., field woodrush, tormentil, heath bedstraw and heather. (2) = ribgrass, yarrow, mouse ear chickweed, buttercup and pearlwort.

this type of hill sward and of miscellaneous species. There was little difference in the fenced and open plots, wild white clover was present to some extent in both plots.

Reviewing this centre as a whole, it will be noted that the entrance of rough-stalked meadow grass and the increasing proportion of wild white clover indicate that both the fenced and open plot areas were increasing in fertility.

At this centre and in contradistinction to the Llety centres the outside or " free " group of manurial plots were very much harder grazed than the fenced plots, for the sheep and cattle of the hill farm kept them in a closely grazed condition over the entire year. This palatability aspect has been previously dealt with (1), but wild white clover had increased in the plots year by year, and this had not only made the grazing more intense, but had increased the palatability of the P plots. Relative marks given for grazing in 1937 compared with those given in 1933 illustrate this :

Bwlchrosser		*1933.*	*1937.*
Open plots.	CaPKN	10.0	10.0
	PKN	7.9	5.0
	Ca	8.9	9.0
	P	5.7	8.5
	Control	2.7	2.5

In regard to density, the total number of tillers was greater in the open plots

LLETY FESCUE.

The data for the fescue-bent plots at the Llety centre are given in Table II. The CaPKN fenced plot was almost entirely composed of bent by 1935, but by a year later rough-stalked meadow grass was contributing 18½ per cent. of the tillers and there was also 11 per cent. of fescue. The open plot was a mixture of fescue and bent with the fescue still dominant in the later years. The fenced and open PKN plots were directly opposite in their fescue-bent relationships. The proportion of bent in the open plot, however, increased to over 50 per cent. by 1937. Fescue was the dominant grass in both the fenced and the open Ca plots, but there was a greater proportion of this grass in the open plot. Rough-stalked meadow grass was present in the fenced Ca plot as in the fenced CaPKN plot, and it is noteworthy that only under these two treatments did this grass and wild white clover appear. In the P plots bent was dominant in the fenced, while fescue was dominant in the open grazed herbage. The open plot contained a certain amount of *Molinia* and more miscellaneous species. In the control plots there was again a greater proportion of fescue to bent in the open plot, and also the presence of *Molinia* and heather.

TABLE II.—The composition of the herbage at the Liety-fescue centre for the years 1935-7 based on a percentage tiller estimation.

Year and Plot.	*Position.*	*Fine-leaved fescue.*	*Bent (Agrostis spp.).*	*Rough-stalked meadow grass.*	*Yorkshire fog.*	*Molinea caerulea.*	*Other grasses.*	*Wild white clover.*	*Heather species.*	*Miscel-laneous species.* (1)	(2)	*No. of tillers per 6in. x 6in.*	*Per cent. bare ground.*
1935.													
CaPKN ...	Fenced ...	T	100	—	—	—	—	—	—	—	—	430	3½
	Open ...	32½	67	—	—	—	—	—	—	½	—	762	1
PKN ...	Fenced ...	11	89	—	—	—	—	—	—	—	—	536	2
	Open ...	70	29½	—	—	—	T	—	—	½	—	638	10½
Ca ...	Fenced ...	62½	34½	—	—	—	½	—	—	2½	—	576	1½
	Open ...	72	26	—	—	—	—	—	—	2	—	700	5
P ...	Fenced ...	40½	57	—	—	—	—	—	—	2½	T	651	2
	Open ...	69	28	—	—	1	—	—	—	2	—	730	1
Control ...	Fenced ...	51	43½	—	—	—	T	—	—	5½	T	540	4
	Open ...	71	19	—	—	2½	1	—	2½	4	—	672	5½
1936.													
CaPKN ...	Fenced ...	11	69½	18½	—	—	—	1	—	—	—	505	2
	Open ...	78½	14	—	—	T	—	—	—	7½	—	636	1
PKN ...	Fenced ...	16	83½	—	—	—	½	—	—	—	—	321	18½
	Open ...	86	10½	—	—	—	½	—	—	3	—	520	25
Ca ...	Fenced ...	62½	33½	—	—	—	½	—	—	3	½	468	11
	Open ...	86	7½	—	—	—	½	T	—	6	T	715	5
P ...	Fenced ...	54	42	—	—	—	T	—	—	1	—	510	6½
	Open ...	78	10	—	—	3	T	—	2½	6½	T	685	7
Control ...	Fenced ...	66½	14½	—	—	—	3	—	—	16	T	440	7½
	Open ...	74½	5½	—	—	5	½	—	11½	3	—	540	4½
1937.													
CaPKN ...	Fenced ...	4	79½	15	1	—	—	½	—	T	—	407	2½
	Open ...	65½	32	—	—	—	—	—	—	2½	—	468	—
PKN ...	Fenced ...	2½	88½	—	9	—	—	—	—	—	—	346	7
	Open ...	44	55½	—	—	—	—	—	—	½	T	271	—
Ca ...	Fenced ...	52	40	2½	—	—	—	1½	—	1	3	406	2
	Open ...	70½	23	—	—	—	T	T	1	5½	T	469	—
P ...	Fenced ...	12½	84	—	2½	—	1	—	—	T	—	326	1
	Open ...	74	16½	—	—	3½	T	—	T	6	—	429	—
Control ...	Fenced ...	48½	47	—	—	—	T	—	—	4	½	416	½
	Open ...	59	18½	—	—	3½	2	—	8	9	T	395	—

Other grasses = Heath grass and sweet vernal. Miscellaneous species (1) = Carex spp., field woodrush, tormentil, heath bedstraw, and bilberry.
(2) = Yarrow, mountain pansy and speedwell (*Veronica officinalis*).

As at the previous centre, there is evidence of improved fertility by the appearance of rough-stalked meadow grass and, in the case of this centre, Yorkshire fog in certain of the fenced plots. In these Llety plots, however, this improvement is confined to the fenced plots alone. The density is again greater in the open plots.

LLETY-MOLINIA.

The data for this centre are given in Table III. In the fenced CaPKN plot occurred the greatest change in botanical composition of any plot in the experiment. The initial change took place during the first and second year and consisted of the disappearance of the *Molinia* under grazing and manuring, and the increase of fescue and bent. By 1935 this phase had altered, and lowland grassland species had not only made an appearance but were becoming important ingredients in the sward. From 1935, rough-stalked meadow grass had increased from one-fifth to two-thirds of the total tillers, and white clover from a trace to one-tenth. Annual meadow grass was also present, but its proportion had decreased over the three-year period as the other two plants had increased. The number of tillers of Yorkshire fog was large in 1936 and 1937, while those of the indigenous fescue and bent were very small. Altogether the herbage of this plot resembled that of a highly fertile lowland pasture. The open CaPKN plot was of a very different nature, consisting of a mixture of the native grasses with fescue dominant in the later years. The contrast between the fenced PKN plot and the fenced CaPKN plot shows very decidedly the influence of lime. No rough-stalked meadow grass or wild white clover appeared in the fenced PKN herbage, but small amounts of annual meadow grass and Yorkshire fog were present. Bent greatly exceeded fescue in this plot and there was an almost entire absence of *Molinia*. This latter grass and *Nardus* were abundant in the open plot of this treatment and the proportion of fescue exceeded that of bent. The herbage of the fenced Ca plot consisted chiefly of fescue throughout the period, but by 1937 rough and smooth-stalked meadow grass contributed appreciable numbers of tillers, and the clover which had made an appearance in this plot in 1935 had increased to some extent. The result was a more mixed herbage than on the remaining plots.

The open Ca plot consisted chiefly of fescue and *Molinia*. In the fenced P plot there were still some tillers of *Molinia* and *Nardus*, and bent was dominant, in contrast to which the open plot consisted chiefly of fescue, and approximately one-quarter

Table III.—The composition of the herbage at the Liety-Molinia centre for the years 1935-7 based on a percentage tiller estimation.

Year and Plot.	Position.	Fine-leaved fescue.	Bent (Agrostis spp.).	Molinia caerulea.	Nardus stricta	Rough stalked meadow grass.	Smooth stalked meadow grass.	Annual meadow grass.	Yorkshire fog.	Wild white clover	Scirpus caespitosus and Juncus squarrosus.	Miscel-laneous spp. (1)	Miscel-laneous spp. (2)	No. of tillers per 6in. x 6in.	Per cent. bare ground.
1935.															
CaPKN ...	Fenced ...	47½	17½	T	5½	20½	—	9	—	T	—	—	—	519	7½
	Open ...	42½	26½	28½	2½	—	—	—	—	T	—	T	T	524	22½
PKN ...	Fenced ...	19½	77½	—	—	—	—	—	3	—	—	—	—	450	7½
	Open ...	42	8	39½	10	—	—	—	—	—	—	½	—	260	58
Ca ...	Fenced ...	89½	6½	2½	1	—	T	—	—	T	—	½	T	721	5
	Open ...	62	1	35½	—	—	—	—	T	—	½	1½	—	480	6½
P ...	Fenced ...	30	68½	1	—	—	—	—	—	—	½	T	—	624	3
	Open ...	19½	20½	26	—	—	—	—	T	—	3½	½	—	569	10
Control ...	Fenced ...	70½	8½	9½	10	—	—	—	—	—	—	1½	—	639	7
	Open ...	35	2½	58	3	—	—	—	—	—	1½	2	—	415	10
1936.															
CaPKN ...	Fenced ...	6½	18	—	—	49½	—	4½	11	7½	—	—	—	306	37½
	Open ...	77½	8	14½	—	—	—	—	—	—	—	—	—	580	17
PKN ...	Fenced ...	16½	77½	—	—	—	—	6	—	—	—	—	—	292	36½
	Open ...	34½	15	26½	18	—	—	6	—	—	—	—	—	239	32
Ca ...	Fenced ...	73½	16	1	2	—	—	—	5	2	—	½	T	130	30
	Open ...	76½	½	23	—	—	—	—	—	—	—	T	—	650	12
P ...	Fenced ...	42½	52½	1	2	—	—	—	—	—	2	T	—	425	22
	Open ...	74	T	20	—	—	—	—	—	—	5	1	—	645	6
Control ...	Fenced ...	68½	15½	6	5½	—	—	—	—	—	—	4½	—	705	5½
	Open ...	28½	T	59	3	—	—	—	—	—	1	8½	—	388	10½
1937.															
CaPKN ...	Fenced ...	2½	2½	1	—	66	—	3	13	10	—	—	2	326	7½
	Open ...	76	1	21½	1½	—	—	—	—	—	—	—	T	403	23
PKN ...	Fenced ...	7	85½	—	—	—	—	3½	1	—	—	—	—	326	9
	Open ...	38	24	26½	10½	—	—	—	1	—	—	T	—	412	14½
Ca ...	Fenced ...	54½	3½	2	2	12½	15	—	1½	4½	½	½	½	317	1.
	Open ...	67½	2	28½	1½	—	—	—	—	—	—	½	—	435	—
P ...	Fenced ...	31	66	T	—	—	—	—	—	—	—	T	—	361	16½
	Open ...	63½	4½	31½	—	—	—	—	—	—	—	½	—	425	3
Control ...	Fenced ...	84	6½	4½	3	—	—	—	—	—	—	2	—	424	1
	Open ...	21½	1	60½	½	—	—	—	—	—	7½	9	—	320	—

Miscellaneous species (1) *Carex* spp, field woodrush, tormentil, heath bedstraw, heather and bilberry. (2) Pearlwort and mouse ear chickweed

TABLE IV.

The composition of the herbage cut for hay and aftermath for the years 1935-7 based on a percentage tiller estimation.

Year.	Centre and plot.	Fine-leaved fescue.	Bent (Agrostis spp.).	Molinia caerulea	Nardus stricta	Other grasses. (1)	Other grasses. (2)	Miscellaneous spp. (1)	Miscellaneous spp. (1)	No. of tillers per 6in. x 6in.	Per cent. bare ground
	Llety-fescue										
1935 ...	CaPKN ...	23½	76	—	—	T	—	½	—	562	10½
	Control ...	71½	24½	—	—	—	—	4	—	566	7½
1936 ...	CaPKN ...	36	63½	—	—	T	T	½	—	540	7
	Control ...	67	27	—	—	1	—	5	—	520	2
1937 ...	CaPKN ...	52	45½	—	—	½	½	1	½	506	2¼
	Control ...	32	21½	—	—	3	—	13½	—	514	1
	Llety-Molinia.										
1935 ...	CaPKN ...	56	12	2	—	—	—	T	—	651	8
	Control ...	51	6½	36	3½	—	—	2½	½	464	9
1936 ...	CaPKN ...	62	36	2	—	—	—	T	—	510	6
	Control ...	48	12	29	3	—	—	8	—	480	12
1937 ...	CaPKN ...	69½	24½	5	1	—	—	T	—	457	5
	Control ...	50½	2	28	3½	—	—	16	—	326	14½

Other grasses (1) Heath grass and sweet vernal.
(2) Cocksfoot, timothy and tall fescue.

Miscellaneous species (1) = *Carex* spp., field woodrush, tormentil, heath bedstraw, heather and bilberry.
(2) = Yarrow and speedwell.

of the total tillers were *Molinia*. Fescue was the main species in the fenced control plot, and *Molinia* and *Nardus* were present in greater proportion than in the other fenced plots. Their contributions diminished, however, from 1935 to 1937. In the open plot *Molinia* was the dominant grass and the *Scirpus, Juncus* and the miscellaneous species group were more abundant than in the fenced herbage.

The botanical changes resulting at this centre were greater than those at the other centres, and the alteration of herbage in the fenced manured plots resulted in the entrance and abundant growth of lowland species. These changes in the herbage brought about an increase in the amount of bare ground among the plants in the fenced plots, but the large area of bare ground in the open CaPKN and PKN plots was caused by an application of sulphate of ammonia given in the spring of 1933 under conditions which caused the herbage to be largely killed off. These plots had not regained a normal covering of herbage even by 1937.

THE CUT PLOTS.

The data for the plots cut for hay and aftermath are given in Table IV At the fescue-bent centre, bent comprised three-quarters of the herbage of the manured plot in 1935, but this proportion decreased to 1937. A few isolated plants of cocksfoot, timothy and tall fescue appeared in the herbage of this plot in 1935. Fescue exceeded bent throughout the period in the control plot and there were greater proportions of miscellaneous species in the herbage of this plot. At the *Molinia* centre the proportions of this grass in the manured herbage were small. Fescue was the dominant grass, and its proportions increased for 1935-7 as in the corresponding plot of the other centres. This grass was also the chief ingredient of the control herbage, but *Molinia* exceeded one-third of the total tillers in 1935, and this proportion was scarcely decreased by 1937. *Nardus* was also present, while the proportion of miscellaneous species greatly exceeded that for the fenced plot, heather being chiefly responsible for the increase.

Discussion and Summary.

A perusal of the foregoing data indicates that the changes in the botanical composition of the plots have been continuous since the commencement of the experiment. The direct comparison between the control and freely grazed herbage in 1934 showed that bent had considerably increased and fine-leaved fescue had correspondingly decreased in the fenced manured

plots of the Llety fescue centre, but that under free grazing conditions the opposite was the case. This position has in general been maintained throughout the three subsequent years, but there have been some increases of fescue in the fenced plots and occasional increases of bent in the open plots, which indicate that the relationships of these two grasses under the two methods of grazing have not reached a fixed state. Under the system of cutting for hay and aftermath, bent exceeded fescue in number of tillers from 1934 to 1936 in the manured herbage, but the reversal of position is again evident in that the proportions of bent were progressively less in each of these three years, and in 1937 the fescue actually exceeded the bent. In the control cut plot the fescue maintained a dominant position throughout the experiment. At the more fertile and sheltered Bwlchrosser centre fine-leaved fescue and bent composed the bulk of the herbage, but there was not the same reaction to controlled *versus* free grazing conditions in their relationship as at Llety. As previously pointed out, the "free" plots at Bwlchrosser were grazed very much harder than the controlled plots. At the Llety centres, on the other hand, the heavier grazing took place under controlled conditions. The herbage of the fenced PKN plot was three-quarters bent by 1934 and this proportion increased up to 1937, but the behaviour of the herbage in this plot was exceptional.

The composition of certain plots at Bwlchrosser was changed to a marked extent by smooth-stalked meadow grass which increased to large amounts in the fenced CaPKN and PKN plots and, more particularly, in the fenced Ca plot, by wild white clover which increased in most of the fenced and open plots, especially the open CaPKN, Ca and P plots; and by the volunteer appearance of Yorkshire fog in 1932 and rough-stalked meadow grass in 1936. It is noteworthy that of these species, only the clover occurred in the control plots. Traces of wild white clover and of smooth-stalked meadow grass were present in the herbage of this centre before the trial commenced in 1930, and under the conditions of the experiment the clover slowly increased in all plots except those under PKN. By 1935 the proportions of clover were far greater, and by 1936 amounted to one-fifth of the total tillers in the open CaPKN and PKN plots and approximately one-tenth in the open Ca plot. The presence of clover had increased the palatability of the open plots in the earlier years of the trial (1), and the effect of this thick growth of clover on these isolated plots on the hillside in the latter years resulted in their being continually hard grazed by the sheep and cattle of the farm. In

addition, the relative palatability of the P plot became almost equal to that of the CaPKN plot. The contrast between the fenced and open Ca plots at this centre was remarkable in that the former was dominantly smooth-stalked meadow grass while the latter only contained 5 per cent. of this grass and 25 per cent. of miscellaneous species, chiefly *Carex* and ribgrass. Almost without exception, the density of the sward of the openly grazed plot was greater than the corresponding fenced ones, and the same remark applies to the Llety-fescue centre. The reason for this, however, is different for the two centres. At Bwlchrosser the outside plots were grazed so continuously hard that the plants composing them could only grow by tillering and adopting a sub-prostrate habit, while at the Llety-fescue centre there was much more high tillering fescue in the outside plots than in the fenced herbage.

The entrance of rough-stalked meadow grass, Yorkshire fog and wild white clover into the herbage of the Llety centres marks the commencement of a further change in the botanical composition. The fog appeared in 1934 and the other two species in 1935. The meadow grass and clover were confined to the fenced plots which had received lime with a trace of clover in the limed open plots. In the herbage of the CaPKN plot at the *Molinia* centre occurred a great economic improvement. At the commencement of the trial in 1930 there was over 70 per cent. of *Molinia* and 10 per cent. of *Nardus* in the herbage. By 1934 the plot consisted almost entirely of bent and fescue, but by 1937 these two grasses together only amounted to 5 per cent of the herbage, while volunteer lowland grasses and wild white clover composed 92 per cent. In August of the same year it was estimated that white clover was producing 35 per cent. of the keep in the CaPKN plot and 17 per cent in the Ca plot. The marked contrast of the fenced PKN plot where only 7½ per cent. of these lowland grasses and no clover occurred shows again the great effect produced by the addition of lime to the fertilizers. It is apparent from the resulting herbage that the application of lime to the CaPKN and Ca plots in 1930 and again in 1935 had a considerable effect in overcoming the natural acidity of these soils. In this connection Davies and Chippindale (4) mention that the top 5½ inches of the Llety *Molinia* soil had a pH value of 3.76, and in a later publication on an experiment at Llety, Davies and Milton (5) mention the volunteer appearance of wild white clover in the herbage of cut plots which had received both basic slag and limestone, and its failure to appear where neither of these manures had been applied. From an ecological point of

view it is interesting how lowland grassland plants were able to appear and increase in these hill swards without a single seed having been sown. It illustrates how soil can become contaminated with the seeds of plants from other environments when sheep are moved from one farm to another and from the cultivated fields to the hill grazings of the same farm. There is also the possibility of seed carrying through the medium of the bags used for the yield sampling done in the earlier years of the trial and the boots and clothing of the workers. The data point to the fact that some such means caused the presence of the three meadow grasses, Yorkshire fog and wild white clover at the two Llety centres of the experiment, for it is known from an investigation into the buried viable seeds of these areas (6) that only seeds of the native species were present in the soils. It is significant that the lowland species which occurred in the grazed plots were species usually associated with pastures, and that the few lowland plants which occurred in the manured fescue cut plot were of a hay type. It is obvious from this that of the total number of species accidentally carried to these plots by the possible means mentioned above, the management in terms of manuring, grazing or cutting decided which should gain a footing. It has been evident from the foregoing data which of the manurial treatments were most efficacious in helping the growth of these volunteer species. Bearing on this question, Thomas (7) reporting on the Cahn Hill investigations mentions the necessity for applications of calcium and phosphate to enable cultivated species to establish and grow on hill soils. The influence of the method of grazing in the present experiment must be borne in mind, for it was only under controlled grazing that any appreciable change in this direction was made.

As mentioned in the earlier reports of this experiment, *Molinia* decreased under grazing in the fenced manured plots as it did in a series of cut plots investigated by Davies and Jones (8) working on the same Llety area. The decreasing proportions of *Molinia* and *Nardus* in the grazed but not manured fenced plot of the present trial indicate that grazing alone is slowly making for an almost entire fescue-bent sward at this Llety-*Molinia* centre, while the much greater proportions of *Molinia* in the herbage of the control cut plot show this method of cutting twice a year to be largely ineffective in producing the change. In regard to this differential reaction of *Molinia* to grazing *versus* cutting on hill swards it is interesting to find that the results of Jones (9) for this species in grazed and mown plots on a lowland marsh were similar. The increase of heather on the unmanured plot cut for

hay and aftermath of the Llety-*Molinia* centre where sheep were excluded is in agreement with the investigation on the influence of sheep on hill grazings reported upon by Fenton (10). Heather was naturally prevalent in this particular area of the present trial, and whereas grazing checked its growth, the lenient system of cutting encouraged it.

Acknowledgments

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THE YIELD OF CERTAIN MISCELLANEOUS HERBS COMPARED WITH GRASSES WHEN GROWN IN DRILLS.

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The miscellaneous herbs of grassland are present to some extent in practically all swards. In a first class perennial rye-grass-wild white clover sward there may be only an occasional " weed " present, but in the majority of pastures the miscellaneous herb group forms an appreciable quantity of the herbage offering to the grazing animal.

The importance of this ingredient of swards has been realized, and several workers in various countries have carried out investigations on the subject.[1] The chemical analysis of a large number of miscellaneous herbs has been studied at Aberystwyth (1), and an investigation has been made into the number of species and the relative quantities of them consumed by stock on all types of grazing land (2). The data obtained demonstrated the value of this group of plants by showing that many species are grazed along with the grasses and clovers of the swards, and at certain times are even selected in preference to the main constituents. Furthermore, several of the generally well grazed herbs were shown to have a high chemical value. It was realized that the grazing would benefit by having certain of these species present in hill pastures, and the seeds of particular species have been included in sowings on the Cahn Hill lands (3).

It was considered that an investigation into the yield of certain of these miscellaneous herbs compared with grasses would add to the information already acquired.

Material and Methods.

The trial (E. 186) was commenced on the Welsh Plant Breeding Station in 1935. It was of a preliminary nature, and consisted of sowing six species of miscellaneous herbs and two grasses in drills 2 ft. apart and 20 ft. in length. The sowing took place in May on land previously growing single plants of grasses for genetical study, and the rate of seeding was 6 viable seeds per linear inch for each species. The herbs used were ribgrass (*Plantago lanceolata* L.), dandelion (*Taraxacum officinale*

[1] See reference (2) for a bibliography.

Weber), cat's ear (*Hypochœris radicata* L.), yarrow (*Achillea Millefolium* L.), smooth hawk's beard (*Crepis capillaris* Wallr.) and buttercup (*Ranunculus repens* L.), and the grasses were cocksfoot (*Dactylis glomerata* L.) and perennial rye-grass (*Lolium perenne* L.). Ten replications of each species were sown. In 1936, the first harvest year, four pasture cuts were taken on six of the replications, and hay and aftermath cuts on the remaining four replications. This system was continued in 1937, but in that year half of each drill was manured in April with 4 cwt. superphosphate per acre, 4 cwt. 30 per cent. potash salts and 2 cwt. sulphate of ammonia. The drills were cut with sheep shears and the produce weighed green on the field. Samples were taken for air-dry weight, but as the drills were kept carefully weeded of all volunteer plants, a botanical separation was not necessary.

Results.

The yields have been expressed in lb. per 1/100th acre of air-dry material. As the drills were 2 ft. apart and 20 ft. long, it has been considered that a drill occupied a ground area of 40 square feet and the yields for this area have been reduced to 1/100th of an acre.

The data for the pasture cuts in the first harvest year are given in Table I.

TABLE I.

The yields in lb. per 1/100th acre of air-dry material for the pasture cuts in the first harvest year (1936).

Species.	Date of cut.				Total.
	21st May.	*19th June.*	*15th August.*	*27th October.*	
Ribgrass ...	25.1	15.9	26.0	10.5	77.5
Dandelion ...	4.2	1.8	1.8	0.6	8.4
Cat's ear ...	10.0	6.2	6.2	2.2	24.6
Yarrow ...	0.5	0.6	0.5	0.3	1.9
Hawk's beard	1.9	2.1	1.6	0.5	6.1
Buttercup ...	4.2	4.3	5.1	1.1	14.7
Cocksfoot grass	1.9	2.6	6.7	3.0	17.2
Perennial rye-grass ...	6.1	6.1	6.0	2.9	21.1

The yields for ribgrass were the heaviest at each date and the total yield of this species was over three times that of perennial rye-grass, and over four times that of cocksfoot. Cat's ear was the next in order, and although it yielded less than one-third the total yield of ribgrass, this species outyielded the two

grasses. Buttercup gave a higher yield than the remaining miscellaneous herbs. The very low yield for yarrow was owing to the poor take of this species throughout the area. All the other species took very evenly. Ribgrass, buttercup and the two grasses gave good August yields relative to their May yields.

The second harvest year's pasture cut data are given in Table II. The yields of the manured herbage have been given as relatives to the unmanured at 100 for each species. Ribgrass again gave the heaviest yield of all the species for every date. This applies to the yields under manuring also. Cat's ear was exceeded in yield by cocksfoot and rye-grass in total yield for this second year, but it far outyielded the remaining miscellaneous herbs other than ribgrass. The relationship of the seasonal yields showed little variation from that of the first harvest year. The quantities, however, were markedly different in that ribgrass, cat's ear and buttercup gave lower yields in the second than in the first year, and dandelion, yarrow and the two grasses gave higher yields for this second year.

TABLE II.

The yields in lb. per 1/100th acre of air-dry material for the unmanured pasture cuts in the second harvest year (1937), with the manured herbage relative to the unmanured at 100.

Species.	*Date of cut.* 13th May.	14th June.	7th August.	15th October.	*Total.*
Ribgrass ...	8.8	16.0	12.5	4.5	41.8
	80	93	131	83	101
Dandelion ...	5.1	2.6	1.6	0.4	9.7
	79	112	94	85	90
Cat's ear ...	7.1	6.7	5.9	2.1	21.8
	72	104	76	100	92
Yarrow ...	0.5	0.9	1.2	0.3	2.9
	100	81	77	118	86
Buttercup ...	2.3	4.0	2.6	1.1	10.0
	92	85	98	91	91
Cocksfoot grass	6.8	7.2	8.2	3.2	25.1
	114	106	160	138	180
Perennial rye-grass ...	7.6	8.3	4.7	1.6	22.2
	96	87	153	100	104

With respect to the influence of the manures on the pasture yields it will be noted that there were increases due to the manures at certain dates for all the species with the exception of buttercup. Considering the total for the year, however, the effect of the manures was to depress the yield of miscellaneous herbs and to increase the yield of cocksfoot to a marked extent,

but of perennial rye-grass for the August cut only. Hawk's beard had died out after the autumn cut in the first harvest year.

The aggregate two year unmanured pasture yields are given in Table III and also the relative yields with perennial rye-grass at 100. The data show the marked superiority of ribgrass to the other miscellaneous herbs and to cocksfoot and rye-grass. Cat's ear also exceeded the two grasses in yield, but not nearly to the same extent as ribgrass. It is perhaps remarkable that a very prostrate plant plant like buttercup should have given more than half the yield of perennial rye-grass over the two-year period.

TABLE III.

The aggregate yields in lb. per 1/100th acre of air-dry material for two years pasture cuts and two years hay with aftermath. Also the relative figures with perennial rye-grass at 100.

Species.	*2 years pasture.*		*2 years hay with aftermath.*	
	Yields.	*Relative.*	*Yields.*	*Relative*
Ribgrass ...	119.3	276	95.1	174
Dandelion ...	18.1	42	8.5	16
Cat's ear ...	46.1	107	49.0	90
Yarrow ...	4.8	11	5.6	10
Hawk's beard	6.1*	—	7.9*	—
Buttercup ...	24.7	57	20.7	38
Cocksfoot grass	42.6	98	49.1	90
Perennial rye-grass ...	43.3	100	54.6	100

* First harvest year only.

The hay and aftermath data for the first harvest year are given in Table IV.

TABLE IV.

The yields in lb. per 1/100th acre of air-dry material for the hay and aftermath in the first harvest year (1936).

Species.	*Hay.*	*Aftermath.*	*Total.*
Ribgrass ...	50.2	29.8	80.0
Dandelion ...	3.8	1.3	5.1
Cat's ear ...	23.5	10.4	33.9
Yarrow ...	1.0	1.9	2.9
Hawk's beard	7.0	0.9	7.9
Buttercup ...	9.8	5.0	14.8
Cocksfoot grass	13.6	13.1	26.7
Perennial rye-grass ...	22.6	10.3	32.9

Both in hay and aftermath the ribgrass gave the heaviest yield, exceeding the yields of both cocksfoot and rye-grass by more that double in each case. The cat's ear came next to the ribgrass in the hay cut, although giving less than half the yield, and cocksfoot came next in the aftermath. Buttercup and hawk's beard exceeded dandelion and yarrow in the hay yields, but in the aftermath buttercup greatly exceeded hawk's beard.

The second harvest year's hay and aftermath data are given in Table V, with the manured yields as relatives to the unmanured at 100.

TABLE V.

The yields in lb. per 1/100th acre of air-dry material for the unmanured hay and aftermath in the second harvest year (1937), with the manured herbage relative to the unmanured at 100.

Species.	*Hay.*	*Aftermath.*	*Total.*
Ribgrass ...	6.8	8.3	15.1
	122	134	128
Dandelion ...	2.7	0.7	3.4
	122	100	117
Cat's ear ...	10.2	4.9	15.1
	—*	—	—
Yarrow ...	1.0	1.7	2.7
	86	90	89
Buttercup ...	3.9	2.0	5.9
	84	83	81
Cocksfoot grass	12.1	10.3	22.4
	98	150	122
Perennial rye-grass ...	15.8	5.9	21.7
	94	128	103

* No cat's ear in the manured series.

It will be observed that the relationship of this second harvest year's hay and aftermath data to that of the first is vastly different from that of the pasture data. In this case there has been a pronounced drop in yield for every species from the first to the second year both in hay and in aftermath. The yields of yarrow cannot be considered as an exception by reason of the patchy condition of its drills. Ribgrass gave a lower yield in the hay than cat's ear and the grasses, and was exceeded by the grasses in the aftermath. Dandelion, yarrow and buttercup gave very low yields, while the total of the hay and aftermath yields was lower than the total of the pasture cuts for this second year for all the species. In regard to the action of the fertilizers on the yields of the hay and aftermath in the second harvest year, the response was greater for ribgrass and dandelion than it was under pasture. The yields of the two grasses were not increased in the

hay, but their aftermath yields were appreciably greater under manuring, while the yields of yarrow and buttercup were depressed.

The aggregate hay and aftermath yields for the two years are given in Table III and relative yields with rye-grass at 100. Ribgrass again occupies the superior position. All the remaining species are less than perennial rye-grass, while cat's ear and cocksfoot gave similar yields. The remaining species are low in comparison.

Considering the relative figures for the two systems of cutting, it will be noted that every species compared more favourably with perennial rye-grass under pasture conditions than under hay and aftermath conditions of cutting.

Discussion and Summary.

The most striking fact shown by the data is the relationship of the yields of ribgrass to the other miscellaneous herbs and, more particularly, to cocksfoot and perennial rye-grass. Ribgrass gave the greatest yield for each date in the pasture cuts of both harvest years, and in the hay and aftermath cuts in the first year. Its yields were only exceeded by the two grasses and by cat's ear in the hay of the second harvest year, and by cocksfoot in the aftermath of the same year. The yields of cat's ear came next in order in the miscellaneous herb group. Although this species gave much lower yields than ribgrass, it exceeded cocksfoot and perennial rye-grass in the first harvest year's yields of pasture and the total of hay and aftermath, and in the second year its pasture yield was approximately equal to rye-grass, but its hay and aftermath yields were lower. Under pasture conditions buttercup gave more than half the yield of rye-grass, and dandelion rather less, while yarrow and hawk's beard gave low yields. Under the two-cut system for hay and aftermath, the relationship of the yields of all the miscellaneous herbs was lower in comparison with the grasses than under the four-cut pasture system. The condition of hay and aftermath production in 1937, the second harvest year, had a depressing effect compared with pasture for all the species, for the total weight of hay with aftermath was less than the sum of the pasture cuts for that year.

The effect of the manures which were applied in the spring of the second harvest year, influenced the species in a different manner. Under pasture cutting the general effect on the miscellaneous herb group was to depress the yield, although at individual dates most species showed an increased yield. Under hay and

aftermath, ribgrass benefited by the fertilizers, as also did dandelion under hay conditions. Buttercup was depressed in yield by the fertilizers under both systems of cutting, but the grasses benefited with the exception of their behaviour for individual cuts.

In conclusion it may be stated that this was in the nature of a preliminary trial, and conducted under conditions which do not prevail in actual practice, for the miscellaneous herbs of grasslands occur as scattered plants among the grasses and clovers of the sward, and not as pure species growing in an isolated position. Nevertheless, the data have given information on the capacity of some of these herbs to produce yields if given the opportunity to do so, and in view of the data referred to in the early part of this paper, this fact is of importance. With respect to future work on the yields of miscellaneous herbs, these drill data have been of sufficient interest to warrant the commencement of a plot-sward trial.

Acknowledgements.

The writer desires to thank Professor R. G. Stapledon, C.B.E., M.A., at whose instigation this experiment was commenced.

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A COMPARISON OF THE HERBAGE YIELDS FROM BROADCAST PLOTS *VERSUS* CULTIVATED DRILLS OF CERTAIN SPECIES AND STRAINS OF GRASS.

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The usual method of broadcasting the seeds of grasses and clovers when sowing down a ley has been departed from to serve various purposes. The chief of these is the sowing of the seeds of these species in drills for the investigation of the individual differences of numerous strains of the same species and, more particularly, the growing of grasses in drills for the purpose of seed production (1). An experiment commenced on the Welsh Plant Breeding Station in 1930 on the chemical composition of grasses grown in plots and in drills (2) showed that the nitrogen content of the grass in drills was consistently higher than in the same grass grown in a mixture or in pure plots whether grown as pasture, hay or aftermath. The method of growing grass in cultivated drills has been adopted on the Cahn Hill Improvement Scheme for the purpose of providing winter keep for the sheep. Timothy grass grown in this way considerably increased the quantity of available keep (3), and the chemical analysis of the herbage compared very favourably with other sown areas used for the same purpose (4). It has been observed in the extensive acreage under seed production, moreover, that the growth of leafage from the individual plants is usually very luxuriant.

It was considered advisable to have a critical experiment in order to obtain data on the yields given by the same grasses sown broadcast and in cultivated drills, and to adopt a system of cutting the herbage which would be suitable for the production of grass for grass-drying.

Material and Methods.

The experiment (E. 182) was sown at the Station in June, 1934, on an area cropped in 1933 with wheat, and consisted of broadcast plots of 1/300th acre alternating with drills 2 ft. apart and 10 ft. long. Five Station bred grasses were sown. These comprised a late pasture-hay strain of perennial rye-grass, S. 101; a pasture-hay strain of cocksfoot, S. 26; a dense hay strain of cocksfoot, S. 37; a pasture strain of timothy, S. 48; and a hay

strain of timothy, S. 51. The sowing of the plots and drills was as single species and also with the addition of *Lotus corniculatus* (bird's-foot trefoil) to find if the presence of a legume would influence the yield of the associated grass. The unit of lay-out was a broadcast single species plot, then five drills of the same grass and then a broadcast plot of the same grass with the addition of *Lotus*. The second drill was used as a single species drill and the fourth as grass with *Lotus*. The remaining drills were used as buffers. As there was a marked soil differentiation in the area of ground, ten replications of the above unit were sown for each of the five grasses and randomized over the block. One section of the area was sown with drills of narrower spacings, viz., 20 inch, 16 inch. and 12 inch, in order to obtain additional information. Four drills of the same grass comprised the unit for these spacings These units were not replicated, but they were all on uniform soil and in the results, comparisons of their yields have been made with adjacent 2 ft. drills and with plots on the same soil.

The soil was in a low state of fertility at the commencement of the experiment and liberal dressings of manures were given in consequence. Twenty loads to the acre of farm yard manure, 4 cwt. of slag, 3 cwt. of kainit and $1\frac{1}{2}$ cwt. of nitro-chalk were given before sowing. During 1935 a cwt. per acre of nitro-chalk was given after each cut. In the spring of 1936 superphosphate at 3 cwt. per acre, kainit at 3 cwt., and nitro-chalk at $1\frac{1}{2}$ cwt. were given, and incremental dressings of nitro-chalk as in 1935. Fishmeal at 10 cwt per acre was given in the spring of 1937. These manures were applied to the whole area in each case.

The management after the seeding year (1934) when one autumn cut was made, consisted of taking four cuts a season, the time of cutting being determined by the condition of the herbage. The produce was weighed green on the field and samples taken for oven drying and for botanical separations. The plots and drills were cut with a scythe, the workers showing considerable skill in cutting the drills to the same level as the plots. After each cut, the ground between the drills was rotary cultivated. This had a stimulating effect upon the growth of the drills and the edges of the plots. Consequently a six inch boarder was cut away from each plot before the plot was cut for weighing.

After the first harvest year's data (1935) had been obtained, half the area was fenced off and during the second harvest year, sheep grazed the herbage on one section on the dates that cuts were made on the other section The entire area was again cut in the third year and the influence of the grazing on subsequent yield obtained.

Results.

The yields of the broadcast plots and of the drills have been expressed in lb. per 1/100th acre of oven dry material. As drills sown 2 ft. apart occupy a ground area of one foot each side of the centre of the drill, and therefore a 19 ft. long drill occupies an area of 38 sq. ft., a direct comparison with broadcast sowing can be made.

Lotus did not take in the drill sowings to an extent which warranted keeping these drills separate for that purpose. Consequently after the first harvest year the three central drills of the unit were cut and weighed as single species drills. The *Lotus* contributed to the plot yields in the second and third harvest years, and the two kinds of plots have been dealt with separately for these years, but for the previous yields the plots have been averaged.

The data for the autumn cut in the seeding year and for the total of four cuts in the first year are given in Table I.

TABLE I.

The yields in lb. per 1/100th acre of oven dry material for the single species plots and 2 ft. drills in the seeding year (1934, one cut) and in the first harvest year (1935, four cuts).

	1934				1935			
	Sown species.	*Other Grasses.*	*Weeds.*	*Total.*	*Sown species.*	*Other Grasses.*	*Weeds.*	*Total.*
Plots.								
Perennial rye-grass	35.5	1.8	0.9	38.2	50.4	8.3	4.3	63.0
Cocksfoot S. 26 ..	33.1	3.6	1.9	38.9	40.4	10.2	5.6	56.2
Cocksfoot S. 37 ..	29.9	3.7	1.6	35.2	37.0	12.0	5.1	54.4
Timothy S. 48 ..	24.1	14.1	1.5	40.0	48.1	28.8	8.9	85.8
Timothy S. 51 ..	22.9	14.1	3.2	40.2	49.9	30.1	7.5	87.5
2 ft. drills								
Perennial rye-grass	6.1	0.4	0.1	6.6	27.1	2.6	0.9	30.6
Cocksfoot S. 26 ...	4.2	0.6	0.1	4.9	26.8	7.7	1.3	35.8
Cocksfoot S. 37 ..	3.5	0.7	0.2	4.4	25.5	6.6	1.3	33.1
Tomothy S. 48 ...	3.3	0.9	0.3	4.5	19.9	8.0	3.2	31.1
Timothy S. 51 ...	3.7	0.6	0.2	4.5	18.8	10.4	2.6	31.8

Other grasses .. Yorkshire fog, rough-stalked meadow grass, annual meadow grass and bent.

Weeds - Buttercups, daisy, mouse-ear-chickweed and ribgrass.

The sown species yields for the autumn cut in the plots compare very favourably with the total weight of sown species for the entire 1935 season. The autumn drill yields, however, are small compared with the 1935 drill yields, which shows that the

herbage in the drills was much slower in production than the plot herbage. This was owing to the fact that although the height of the leafage was not lower in the drills than in the plots, the width of the herbage in the drills in the seeding year was very narrow and therefore the yield per unit of area was small. By the first harvest year the plants in the drills had tillered out into the bare soil on either side to some extent. It will be noted that the plots outyielded the drills both in regard to sown species and total produce for the seeding and first harvest year. This excess of yield was greater in the case of the two strains of timothy than for the other grasses. In regard to the individual grasses, perennial rye-grass gave the highest yield of sown species in the plots and in the drills.

The second harvest year's data are given in Table II.

TABLE II.

The yields in lb. per 1/100th acre of oven dry material for the single species plots and 2 ft. drills in the second harvest (1936, four cuts) and also the yields of Lotus in the grass plus Lotus plots.

	Sown species.	Lotus.	*White wild clover.*	*Other grasses*	*Weeds.*	*Total.*
Plots.						
Perennial rye-grass ..	45.4	(4.1)	2.8	7.0	4.2	59.4
Cocksfoot S. 26 ...	45.3	(4.3)	0.3	5.3	3.4	54.3
Cocksfoot S. 37 ...	39.1	(1.9)	5.1	11.1	6.0	61.6
Timothy S. 48 ...	38.2	(7.3)	5.4	24.0	6.8	74.4
Timothy S. 51 ...	43.8	(13.6)	3.7	20.2	7.4	75.1
2 ft. drills.						
Perennial rye-grass ...	31.5	—	0.2	1.9	0.6	34.2
Cocksfoot S. 26 ...	47.8	—	—	4.8	0.6	53.2
Cocksfoot S. 37 ..	37.2	—	0.3	7.8	1.6	46.9
Timothy S. 48 ...	21.2	—	0.9	10.3	3.9	36.3
Timothy S. 51 ...	25.6	—	0.2	9.8	2.5	38.1

In this year the yields of sown species in the plots were less than for the first harvest year for the rye-grass and the two timothy strains, but the yields for the drills were greater in each case. The result was that the drill yield for the S. 26 strain of cocksfoot exceeded that for the plots, while the S. 37 cocksfoot yields were very similar. The plots far exceeded the drills for the remaining grasses, however, and the greatest difference was again in the case of timothy. *Lotus* contributed to the yields of the plots in the series where this species was sown. It did not affect the yield of the grass in the mixture, and the total produce was only increased by the actual weight of the *Lotus* itself. Wild white clover had come into the plots and drills by 1936.

The third harvest year's data are given in Table III. There was some variation in the plot yields of the grasses between this and the previous year, but in general they were on the same level.

TABLE III.

The yields in lb. per 1/100th acre of oven dry material for the single species plots, the grass plus Lotus plots and the 2 ft. drills in the third harvest year. (1937, four cuts).

	Sown species.	Lotus.	*White wild clover.*	*Other grasses*	*Weeds.*	*Total.*
Plots.						
Perennial rye-grass ...	45.5	-	6.3	13.6	6.5	71.9
Cocksfoot S. 26 ...	47.7	--	2.2	12.7	6.3	68.9
Cocksfoot S. 37 ...	48.0	--	1.9	16.5	6.5	72.9
Timothy S. 18 ...	42.3	--	6.0	28.0	9.5	85.8
Timothy S. 51 ...	10.5	-	5.2	37.1	5.8	88.6
Grass plot plus Lotus.						
Perennial rye-grass ...	13.4	1.8	6.0	13.0	6.2	73.4
Cocksfoot S. 26 ..	19.3	2.8	2.3	13.2	6.5	74.1
Cocksfoot S. 37 ..	49.3	1.9	1.9	17.0	6.7	76.8
Timothy S. 18	12.6	6.8	6.1	28.4	9.5	93.4
Timothy S. 51 ...	11.4	5.5	5.2	37.6	5.9	95.6
2 ft. drills.						
Perennial rye-grass ...	18.6	—	0.2	3.5	1.1	23.4
Cocksfoot S. 26 ...	29.8	-	0.1	3.4	0.8	34.1
Cocksfoot S. 37 .	31.7		0.1	3.0	0.6	35.1
Timothy S. 18 ..	20.3	--	0.3	7.9	8.3	31.8
Timothy S. 51	16.9	--	0.3	10.9	2.7	30.8

The drill yields, on the other hand, had dropped considerably with the result that the yields in the drills compared with those in the plots were less than half for the perennial rye-grass and the two strains of timothy and less than two-thirds for the two strains of cocksfoot. *Lotus* again contributed to the yield of the particular series of plots, but its presence did not influence the sown grass or weeds to any great extent. The wild white clover had further increased in the plots, but extremely little was present in the drill herbage.

In Table IV are given the aggregate yields for the three harvest years for the grasses under broadcast plot and under drill method of sowing, and relative figures for the sown species and total produce yields are given in Table V.

The aggregate yields show that the plots exceeded the 2 ft. drills for each species and strain both in regard to sown grass and total herbage which includes the volunteer species. There were distinct differences among the species in this respect as

TABLE IV.

The aggregate yields for the three harvest years in lb. per 1/100th acre of oven dry material for the single species plots and the 2 ft. drills.

	Sown species.	*Wild white clover.*	*Other grasses*	*Weeds.*	*Total.*
Plots.					
Perennial rye-grass ...	141.3	9.1	28.9	15.0	194.3
Cocksfoot S. 26 ...	133.1	2.5	28.2	15.3	179.4
Cocksfoot S. 37 ..	124.4	7.0	39.6	17.9	188.9
Timothy S. 48	128.6	11.4	80.8	25.2	246.0
Timothy S. 51	131.2	8.9	87.1	20.7	251.2
2 ft. drills.					
Perennial rye-grass ...	77.2	0.4	8.0	2.6	88.2
Cocksfoot S. 26 ..	101.1	0.1	15.9	2.7	123.1
Cocksfoot S. 37 ...	91.4	0.4	17.1	3.5	115.7
Timothy S. 48	61.1	1.2	26.2	10.4	99.2
Timothy S. 51	61.3	0.5	51.1	7.8	100.7

TABLE V.

The relative three-year yields for the plots and 2 ft. drills with the drills at 100. Sown species and total yields.

	Sown species.		*Totals.*	
	Drills.	*Plots.*	*Drills*	*Plots.*
Perennial rye-grass ...	100	183	100	220
Cocksfoot S. 26 ...	100	123	100	146
Cocksfoot S. 37 ...	100	132	100	163
Timothy S. 48 ...	100	209	100	248
Timothy S. 51 ...	100	219	100	250

indicated by the relative figures in Table V, but the relationship between plot yields and drill yields for the strains within the species was very similar both in the case of cocksfoot and timothy. The difference between plot and 2 ft. drill yields was greater for the total produce yields than for the sown species yields on account of the larger amounts of clover, other grasses and weeds per unit of area in the broadcast plots than in the drills.

In regard to seasonal yield of the plots and drills, the percentage contribution of the spring and autumn cuts to the annual yield of four cuts is given in Table VI. The drills gave a greater proportion of their yield in the spring cut for the first harvest year (1935) than did the same grasses in the plots. This was particularly marked for the two strains of cocksfoot. Also in the spring cut of 1936 the drill herbage showed the same characteristic for each species and strain but not to the same degree as in 1935. The spring contributions to the yields in 1937 were very

TABLE VI.

The percentage contribution of the spring and autumn cuts to the annual yields for the broadcast plots and 2 ft. drills.

	Date of cut.					
	1935		*1936*		*1937*	
	3rd May.	*3rd October.*	*20th May.*	*23rd Sept.*	*17th May.*	*19th Oct.*
Plots.						
Perennial rye-grass ...	15	9	25	28	26	15
Cocksfoot S. 26 ...	8	14	24	26	29	16
Cocksfoot S. 37 ...	8	11	24	23	29	11
Timothy S. 48 ...	13	6	27	27	31	8
Timothy S. 51 ...	17	8	30	26	34	10
2 ft. drills.						
Perennial rye-grass ...	21	7	30	21	27	18
Cocksfoot S. 26 ...	18	19	28	19	31	14
Cocksfoot S. 37 ...	20	16	27	22	32	12
Timothy S. 48 ...	21	6	29	21	29	10
Timothy S. 51 ...	25	8	33	19	27	11

similar for plots and drills. With respect to the autumn yields, the proportional contributions of the herbage under the two systems shows little difference for 1935 and 1937, but in 1936 greater contributions were made by the plot herbage in each case. It will be observed that the relationship between the strains within the species was very similar in plots and in drills. The only variation which existed in the mid-season cuts was that the drill herbage gave a slightly lower proportion of their yield for the June cut of each year and a rather greater proportion for the July or August cut.

TABLE VII.

The percentage increase in 1937 of the herbage in the section grazed by sheep the previous year over the herbage of the same section in 1935.

	Plots.	*Drills.*
Perennial rye-grass ...	14	16
Cocksfoot S. 26 ..	10	12
Cocksfoot S. 27 ...	5	19
Timothy S. 48 ...	16	8
Timothy S. 51 ...	10	0

As mentioned above, half the area was grazed by sheep in the second harvest year, and yields taken again over the entire area in the third harvest year. In Table VII are given the

percentage increase data of the herbage in this grazed section over the herbage yields of the same section in the first harvest year before grazing had taken place.

In the plot herbage all species and strains were benefited by the fertilizing and consolidating influence of the sheep, but in the drill herbage one strain of timothy gave no increased yield by the treatment. It is interesting that the perennial rye-grass showed the greatest benefit from the grazing when considering the plot and drill herbage together.

It was mentioned in the early part of this paper that sowings of narrow spaced drills were made in a section of the area. The data from these are given in Tables VIII and IX. In the first of these Tables the annual yields from the three types of spacings are compared with the adjacent 2 ft. drills.

TABLE VIII.

The yields of sown species in lb. per 1/100th acre of oven dry material for the three types of narrow spaced drills compared with the yields of the adjacent 2 ft. drills for each harvest year.

	1935*				1936				1937			
	2 ft	20in	16in	12in	2 ft	20in.	16in	12in	2 ft	20in	16in.	12in.
Perennial rye-grass	41.8	43.4	46.5	46.7	33.0	23.6	39.0	21.1	21.8	30.0	46.5	35.0
Cocksfoot S. 26 .	37.8	44.3	57.3	61.4	19.6	51.0	53.8	57.6	40.2	45.3	55.6	56.0
Cocksfoot S. 37 . .	37.2	38.0	48.8	61.6	41.5	39.6	40.2	43.8	38.4	39.4	31.4	41.8
Timothy S. 48 ...	26.5	33.7	46.4	43.8	36.3	28.9	20.3	36.1	32.8	32.7	22.1	49.7
Timothy S. 51 ...	28.5	32.0	28.9	36.2	33.7	33.6	25.5	32.4	25.0	31.2	25.2	44.2

* Including the autumn cut in 1934

TABLE IX.

The aggregate three-year yields in lb. per 1/100th acre of oven dry material for the narrow spaced drills, the adacent 2 ft. drills and the adjacent broadcast plots. Also relative figures with the 2 ft. drills at 100.

	Drills.				*Plots.*
	2 ft.	*20 in.*	*16 in*	*12 in.*	
Perennial rye-grass . .	96.6	97.0	132.0	102.8	144.5
	100	101	137	106	150
Cocksfoot S. 26 .	127.6	140.6	166.7	175.6	150.8
	100	110	131	138	119
Cocksfoot S. 37 ...	117.1	117.0	120.1	127.2	138.2
	100	100	103	109	118
Timothy S. 48 .	95.6	95.3	77.8	129.9	128.6
	100	100	82	136	134
Timothy S. 51 ...	87.2	96.8	79.6	112.8	137.5
	100	111	92	129	158

It will be seen that in general a narrow spacing gave a higher yield per unit of area than the 2 ft drill. This is the case for every grass and for each year with the exception of the two

strains of timothy in 1936. The yields given by the S. 26 cocksfoot strain were remarkably consistent in increasing from the 2ft. spacing to the 1 ft. spacing each year. The aggregate three-year yields for each kind of drill and for the adjacent broadcast plots given in Table IX clearly show that a 16 inch spacing was the best for perennial rye-grass, and that a 12 inch spacing was the best for the strains of cocksfoot and of timothy when sown in drills. It is interesting to note that the broadcast plot yield of the S. 26 strain of cocksfoot was exceeded by the 16 inch and 12 inch spaced drills, and that the same took place in regard to the 12 inch spacing for the S. 48 strain of timothy, but only to a slight extent in this case. The broadcast yields of perennial rye-grass and the S. 51 strain of timothy were heavier than any of the drill yields by a good margin, and the S. 37 cocksfoot plot yield was appreciably greater.

Discussion and Summary.

The data given by this critical field trial on the relationship of the yields as between broadcast plot and cultivated drill method of growing grass has shown that the usual broadcast method is superior to that of 2 ft. drills over a three-year period. The relationship of the yields during the individual years showed a heavy autumn yield in the seeding year for the herbage in the plots and a very light yield in the drills. The plot yields exceeded those of the drills for the first harvest year, but the yields came closer for the second year, and were even approximately the same in plots and drills for the two strains of cocksfoot. There were still very marked differences for the strains of timothy for this year, however. For the third harvest year the plots greatly exceeded the drills by reason of the former having kept to the same level of productivity as in the previous year, and the latter having dropped in yield. In regard to the aggregate yields for the three years, the perennial rye-grass plots gave 83 per cent. of sown species more than the 2 ft. drills, the strains of cocksfoot approximately 28 per cent. and the strains of timothy more than double the drill yield.

The weights of herbage have been expressed in lb. of oven dry material throughout as it was intended to find what quantity of dry grass was produced. Perennial rye-grass gave the highest aggregate yield of sown species (Table IV) and the plot yield of this grass provided 6.3 tons of dry grass per acre for the three-year period. The quantities of sown species in like terms for the strains of cocksfoot and of timothy would be correspondingly less, but the three-year weights of total produce which include wild white clover, other grasses and weeds came to 8.7 tons for

rye-grass, 8.2 tons for cocksfoot and 11.1 tons for timothy, the large weight for this species being due to the greater growth of the above volunteer plants among its herbage. In actual practice, of course, it is the total produce which is taken for grass-drying, and in the present instance the white clover would be a definite asset, while the other grasses and weeds would have been cut along with the sown grass at a nutritious stage of growth.

The data have further shown that in regard to seasonal yield the drills, when established, gave a greater proportion of their annual yield in the first spring cut during the first and second harvest years compared with the plot herbage, that the *Lotus* failed to obtain a stand in the drill herbage and that the amount of volunteer wild white clover which came into the drill herbage was very small compared with the plots. The effect of sheep grazing, however, was of benefit to the drills as well as to the plots, with one exception.

With regard to spacing the drills at narrower intervals than 2 ft. the data have shown that a spacing of 16 inches gives the highest drill yield for perennial rye-grass and of 12 inches for cocksfoot and timothy. Furthermore, the yields given by one strain of cocksfoot and one strain of timothy in the latter spacing outyielded the adjacent plot yields for these grasses.

As mentioned in an earlier section of the paper, the soil between the drills was cultivated with a rotary cultivator after each cut. The actual rows of grass became wider each year, as the plants tillered further towards the bare soil. By 1937 the space for cultivating between the 2 ft. drills was only one foot. It was still found possible to use the cultivator, however, and even to cultivate between the narrower spacings by means of removing tines from the implement.

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THE MOISTURE CONTENT OF GRASS SEED IN RELATION TO DRYING AND STORING

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Prehistoric man established the practice of laying up reserves of grain methodically, in carefully constructed containers. He had become aware that damp vegetable matter would become heated and decomposed when stored in bulk, and as his very life depended on cereal grain, the pressure of necessity undoubtedly caused him to handle the grain in such a manner as would ensure its remaining in a sweet condition until the next harvest.

It is only comparatively recently, however, that the cause of heating in damp vegetable matter has been investigated. Critical investigations have shown that energy in the form of heat is released in a heap of damp seeds as a result of respiration. Respiration may be defined as the production of energy by the oxidation of organic food reserves, as accelerated by certain enzymes; carbon dioxide and water are characteristic products of this physiological process.

The seed is said to be a poor conductor of heat, and thus the heat energy evolved during respiration accumulates in the seed bulk with the result that, sooner or later, a rise in temperature becomes noticeable.

Moisture has been shown to be one of the more important factors which determine respiration; and extensive reviews of the earlier general literature on moisture and other factors relating to seed storage may be found on reference to Bailey and Gurjar (4), Bailey (2, 3), Lehmann and Aichele (13) and Franck (10).

The retention of viability and energy of germination is directly dependent on the method of handling threshed seeds throughout the storage period, that is, the interval between harvesting and the delivery of the seeds to the final purchaser. This period may be a few months, or perhaps years: and the seeds may have to be transported long distances overseas, in which event careful handling and conditioning, prior to dispatching, are vitally important.

Duvel (9), in a study of the vitality of stored seeds, found that a marked decrease in the percentage of viable seeds accom-

panied an increase in the moisture content and respiration. Iversen and Dorph-Petersen (12) stored small quantities of seeds with different moisture contents in warehouses, and found that the seeds retained their viability for varying lengths of time: the higher the moisture content the shorter the period of retention of viability.

It emerges from the results of these, and several other investigators, working with seeds of different crop plants, that there is a definite correlation between moisture content and the rate of deterioration of seeds. Seeds dried and stored to prevent reabsorption of moisture, have been known to retain their viability far more successfully than undried seeds.

The moisture content of harvested seeds depends on the humidity and temperature of the atmosphere. The atmospheric humidity is high in many parts of western Europe, and the climatic conditions are generally such that seeds contain a comparatively high percentage of moisture. In wet seasons and in wet districts the moisture content of grass seeds often reaches 20 per cent. at harvest time, and such seeds must be dried naturally or artificially to expel the excess moisture. The moisture content at which bagging and storing grass seeds is considered safe, is generally recognised to-day as being about 14 per cent. (Franck (10)). This is, however, merely an approximate value suggested for all species, and no data have been available to indicate whether this empiric value holds good for all grass species under the varying atmospheric conditions of the storage house.

A number of preliminary investigations, the results of which are reported in this paper, were begun at the Welsh Plant Breeding Station in order to obtain more exact information on the problem of moisture in seeds.

The Norm.

The norm, or maximum moisture content at which it is considered safe to bag seeds, was investigated by the writer for seeds of perennial rye-grass (*Lolium perenne*), cocksfoot (*Dactylis glomerata*) and timothy (*Phleum pratense*) Series of experiments were conducted during the summer seasons of 1936 and 1937 in the seed storage house at the Welsh Plant Breeding Station, Aberystwyth.

Newly threshed seeds of two improved strains of each of the three grass species were placed in 4-bushel bags at different moisture contents, as shown in Table 1.

TABLE I.

Showing the moisture content of each lot of grass seeds used to investigate the moisture norms for rye-grass, cocksfoot and timothy.

Species and strain.	*Moisture content per cent. at the commencement of the experiment.*					
	Bags	%	*Bags*	%	*Bags*	%
Perennial rye-grass S. 24	1C 2L	13.7	3C 4L	14.2	5C	14.5
Do. S. 101	1C 2L	14.0	3C 4L	16.4	5C	14.5
Cocksfoot S. 37 ...	1C 2L	12.0	3C 4L	13.2	5C	13.9
Do. S. 143 ...	1C 2L	13.8	3C 4L	13.0	5C	13.4
Timothy S. 48 ...	1C 2L	13.0	3C 4L	13.5		
Do. S. 51 ...	1C 2L	14.9	3C 4L	15.7		

Bags 1 C, 3 C, 5 C – seeds closely packed.
Bags 2 L, 4 L — seeds loosely packed.

TABLE II.

Showing the moisture content (M) changes in bagged seeds of perennial rye-grass.

(Bags 1, 3 and 5, closely packed – C, bags 2 and 4 loosely packed – L)

Strain No.	*Bags No.*	*Initial moisture content.*		*After 2 days*		*After 4 days*		*After 8 days*		*After 14 days*	
		Per cent.	*S.E.*	*M. per cent.*	*S.E.*	*M. per cent.*	*S.E.*	*M. per cent.*	*S.E.*	*M. per cent.*	*S.E.*
S. 24	1 C	13.7	±.027	13.6	±.027	13.5	±.027	13.5	±.027	13.5	±.027
	2 L	13.7	.027	13.8	.028	13.7	.027	13.7	.027	13.8	.028
	3 C	14.2	.030	14.3	.030	14.8	.031	15.1	.032	15.3	.032
	4 L	14.0	.030	14.2	.030	14.4	.030	14.7	.031	14.9	.031
	5 C	14.5	.031	14.6	.031	14.9	.031	15.2	.032	15.5	.034
S. 101	1 C	14.0	.028	14.0	.028	14.0	.029	14.1	.028	14.1	.029
	2 L	14.0	.028	14.0	.028	14.1	.029	14.1	.029	14.0	.028
	3 C	16.4	.033	16.6	.033	16.9	.034	17.5	.036	18.8	.038
	4 L	16.4	.033	16.4	.033	16.7	.034	17.5	.036	18.9	.038
	5 C	14.5	.031	14.5	.031	14.9	.032	15.0	.032	15.6	.034

TABLE III.

Showing the moisture content (M) changes in bagged seeds of cocksfoot.
(Bags 1, 3 and 5, closely packed = C; bags 2 and 4 loosely packed = L).

		Initial moisture content.		*After 2 days*		*After 4 days*		*After 8 days*		*After 14 days*	
Strain No.	*Bags No.*	*Per cent.*	*S.E.* ±	*M. per cent.*	*S.E.* ±	*M. per cent.*	*S.E.* ±	*M. per cent.*	*S.E.* ±	*M. per cent.*	*S.E.* ±
S. 37	1 C	12.0	.014	12.0	.014	12.0	.014	12.0	.015	12.0	.014
	2 L	12.0	.014	12.4	.016	12.3	.015	12.1	.014	12.1	.014
	3 C	13.2	.018	13.3	.018	13.6	.019	13.7	.019	13.9	.019
	4 L	13.2	.018	13.3	.018	13.5	.018	13.6	.014	13.8	.019
	5 C	13.9	.019	13.9	.019	14.1	.020	14.2	.020	14.4	.021
S. 143	1 C	13.8	.019	14.0	.019	14.1	.020	14.1	.021	14.5	.022
	2 L	13.8	.019	13.9	.019	14.1	.020	14.3	.021	14.4	.022
	3 C	13.0	.018	13.0	.018	13.0	.017	12.9	.017	12.9	.018
	4 L	13.0	.018	13.0	.018	12.9	.018	13.1	.017	13.0	.018
	5 C	13.4	.018	13.5	.018	13.6	.017	13.8	.018	13.9	.020

TABLE IV.

Showing the moisture content (M) changes in bagged seeds of timothy.
(Bags 1 and 3, closely packed = C; bags 2 and 4, loosely packed = L).

		Initial moisture content.		*After 2 days*		*After 4 days*		*After 8 days*		*After 14 days*	
Strain No.	*Bags No.*	*Per cent.*	*S.E.* ±	*M. per cent.*	*S.E.* ±	*M. per cent.*	*S.E.* ±	*M. per cent.*	*S.E.* ±	*M. per cent.*	*S.E.* ±
S. 48	1 C	13.0	.032	13.0	.032	13.0	.032	13.0	.033	12.9	.032
	2 L	13.0	.033	13.1	.033	13.3	.032	13.3	.032	13.1	.032
	3 C	13.5	.033	13.6	.033	13.5	.034	13.5	.033	13.6	.036
	4 L	13.5	.033	13.6	.033	13.6	.034	13.5	.034	13.5	.035
S. 51	1 C	14.9	.037	14.9	.037	15.0	.038	15.5	.040	16.3	.041
	2 L	14.9	.037	15.1	.038	15.2	.038	15.6	.041	16.1	.041
	3 C	13.7	.034	13.7	.034	13.9	.036	14.2	.034	14.1	.037
	4 L	13.7	.034	13.7	.034	14.0	.035	14.1	.036	14.1	.036

The seeds in bags 1, 3 and 5, were packed as closely as possible, being pressed down hard, whilst those in the other bags, 2 and 4, were not pressed down. There was thus almost twice as much seed in each of bags 1, 3 and 5, as in each of bags 2 and 4. This was done with the object of finding out if air spaces between seeds in loosely packed bags influenced the moisture in the seeds in any way.

All the bags were closed and placed about a foot apart in a large open bin. The moisture content and the condition of the seeds in each bag were determined after two, four, eight and fourteen days. The experiment was conducted in duplicate and the average results of the duplicates are set out in Tables II, III and IV.

Perennial Rye-grass.

An increment of 0.9° C. above atmospheric temperature was recorded on the fourteenth day in the seeds of the S. 24 strain which had been bagged with 14.2 per cent. moisture content (bags 3 and 4). Seeds of S. 101 (bags 3 and 4) with 16.4 per cent. initial moisture, showed a temperature increase of 1.2° C. above that of the atmosphere on the fourth day, whilst on the fourteenth day the temperature of the atmosphere was 16.7° C. and that of the seeds was 19.2° C. Both S. 24 and S. 101 seeds with 14.5 per cent. initial moisture (bags 5) showed an increase of 1.1° C. above the temperature of the atmosphere on the fourteenth day.

An appreciable amount of germination was found in the bags of S. 101 seeds which had 16.4 per cent. moisture when bagged. A distinct mouldiness was apparent on the fourteenth day in all bags of S. 24 and S. 101 seeds which had initial moisture contents of 14.2 per cent. or more. This mouldiness was noticed on the eighth day in the S. 101 lots with 16.4 per cent. moisture when bagged.

There were no significant changes in the conditions of the perennial rye-grass seeds, S. 24 and S. 101, with initial moisture contents of 13.7 and 14.0 per cent. respectively.

It would appear that in certain instances there are distinct differences in the moisture changes in seeds as the result of different methods of packing, but, in general, the differences are not really significant.

The results in Table II indicate that S. 101 seeds can be bagged with safety when their moisture content is 14 per cent.

The norm may be slightly higher than 14 per cent. but certainly not as high as 14.5 per cent., since seeds bagged at this value become deconditioned. The results with the S. 24 seeds suggest that 14.2 per cent. is unsafe, and that 13.7 per cent. is safe. The changes in seeds of S. 24 bagged with 14.5 per cent. moisture (bag 5), are not significantly different from those in S. 101 (bag 5) seeds, bagged under exactly similar conditions. If, therefore, it is assumed that the reactions to bagging are more or less identical for both strains, then 14 per cent. can be considered as the norm for perennial rye-grass. At the same time 14.2 per cent. must be considered unsafe. This tolerance of 0.2 per cent. is surprisingly minute. The value 14.0 per cent. has been found, in numerous other tests, to be a safe moisture norm, and 14.5 per cent. definitely unsafe. Seeds were bagged at 14.2 per cent. in some cases with comparative safety, but this occurred under cool, dry conditions. Conditions of high humidity and temperature were found unfavourable for bagging seeds of perennial rye-grass when the moisture content was more than 14.0 per cent. The conditions for bagging seeds are considered unfavourable when the humidity is above 80 per cent. and the temperature above 60° F.

Cocksfoot.

Moulds appeared after the eighth day in seeds of cocksfoot S. 143, the initial moisture content of which was 13.8 per cent. (bags 1 and 2). There was no evidence of sprouting, but the temperature on the fourteenth day was 1.1° C. above that of the atmosphere. Similar changes in condition were found in bag 5 of S. 37 seeds, bagged with 13.9 per cent. moisture The seeds of S. 37 with 13.2 per cent., and S. 143 with 13.4 per cent. moisture when bagged, showed a definite increase in their moisture contents, reaching 13.9 per cent. after fourteen days; but the seeds showed no other signs of deconditioning at the end of this period. It was, however, shown that seeds originally bagged with 13.8 and 13.9 per cent. moisture became mouldy and heated, and it was thought that seeds which were bagged at 13.2 and 13.4 per cent., having had their moisture increased to 13.9 per cent. would in all probability develop moulds later on. This was, in fact, found to occur within another four days.

There was no rise in temperature and no signs of deconditioning in seeds of cocksfoot bagged with 13.0 per cent., or less, moisture. The tolerance here again is less than 0.2 per cent., but

further evidence has supported the inference that 13.0 per cent. is a safe value for cocksfoot, and that 13.2 per cent. and over is unsafe.

Timothy.

There was no significant temperature increase and no indication of sprouting in seeds of timothy bagged at 14.9 per cent. (bags 1 and 2), but there was a definite mouldiness after the eighth day. The moisture content of S. 51 seeds bagged at 13.7 per cent. (bags 3 and 4) gradually increased up to the fourteenth day, and there was slight sprouting at the end of this period. There was, however, no apparent change in the condition of timothy seeds bagged at or below 13.5 per cent. moisture.

Germination Tests.

Germination tests of most of the above seed lots were put up at the beginning and at the end of the experiment. Tests were also made, after about three months, on seeds which had been bagged at the lowest moisture contents and had shown no significant changes in their condition throughout the fourteen-day period. The results are set out in Table V. Data obtained with seeds which had remained in an open bin during the fourteen days are also shown in the table.

The results of these tests indicate that seeds of perennial ryegrass deteriorate rapidly if bagged and stored at a moisture content exceeding 14.0 per cent. Seeds of cocksfoot and timothy deteriorate when bagged with moisture contents of more than 13 0 and 13.5 (or 13.6) per cent., respectively. The germination tests also indicate that at or below these moisture contents storage has no detrimental effect on the germination capacity. Storage above these values, which may be regarded as norms, appears to be definitely detrimental.

Conditioning.

The aeration and removal of excess moisture from bulks of newly threshed seeds are generally referred to as conditioning.

It has been pointed out that newly threshed seeds frequently contain 4 to 6 per cent. excess moisture, and also that this moisture must be removed before the seeds can be bagged and stored with safety. Until drying plants have come into more general use, recourse must be had to clean, airy barn floors for conditioning seeds whenever it is necessary.

TABLE V.

Showing the effect on germination capacity of storing in bags the seeds of perennial rye-grass, cocksfoot and timothy, with varying moisture contents.

Species and strain.	*Initial moisture content per cent.*	*Initial germination.*		*Germination capacity.* (a) *After 14 days in bin*		(b) *After 14 days in bag. Concurrent with* (a)		*After 3 months in bag.*	
		Per cent.	*S.E.*	*Per cent.*	*S.E.*	*Per cent.*	*S.E.*	*Per cent.*	*S.E.*
			±		±		±		±
P. rye-grass S. 101 ..	14.9	93.4	0.7	94.0	1.0	94.2	0.9	96.3	0.8
P. rye-grass S. 101 ...	11.5	96.8	0.8	96.9	1.2	78.0	1.4	- -	
P. rye-grass S. 24 ...	13.7	100.0		99.3	0.3	99.1	0.1	100.0	
P. rye-grass S. 24 ...	14.2	98.6	0.7	97.1	1.1	78.1	2.1	—	
Cocksfoot S. 37 ..	13.2	97.2	0.9	96.3	0.9	89.5	1.2	63.1	4.5
Cocksfoot S. 143 ...	13.0	100.0		99.0	0.1	100.0		99.8	0.1
Cocksfoot S. 143 ...	13.4	100.0		100.0		88.4	2.3	- -	
Cocksfoot S. 143 ...	13.8	99.1	0.2	100.0		88.0	1.1	--	
Timothy S. 48 ..	13.5	87.6	1.7	85.9	1.4	90.2	1.3	94.6	1.7
Timothy S. 51 ...	13.7	89.2	1.3	87.8	1.6	71.5	2.1	—	
Timothy S. 51 ...	14.9	92.9	1.5	95.0	1.3	77.6	3.3	--	

Most of the seeds of grass strains bred at the Welsh Plant Breeding Station are produced in bulk by farmers in the counties on the Welsh-English border. Newly threshed seeds are brought into the Station immediately by lorry for treatment and storage.

This section of the paper records the results of observations made on seed bulks stored at the Station seed-house in relation to the moisture content of the seeds, humidity and temperature, during conditioning. Within the scope of this paper, however, it is only possible to indicate the nature of these particular experiments and summarize the main results.

It has long been known (Bailey (2, 3), Coleman and Fellows (5), Dillman (6), among others) that the rate at which moisture can be expelled during conditioning depends largely on the humidity and temperature of the atmosphere in the storehouse. A large amount of data obtained by the writer during the summer and autumn seasons of 1936 and 1937 has yielded some interesting information in this direction. In addition to atmospheric conditions, the rate of evaporation or absorption of moisture by

seeds was found to depend also on the initial moisture content.

It was found that the norms for rye-grass, cocksfoot and timothy can be maintained in atmospheres of 80 per cent. humidity at 60° F. These values were found to represent the average atmospheric conditions in the Station seedhouse during the period from July to October, when seeds are normally brought in for conditioning.

Climatic conditions during this period in 1936 were such that newly harvested seeds contained as much as 18 to 20 per cent. moisture. Such seeds were spread out to a depth of about 12 inches in bins, so as to permit reasonable evaporation. The atmospheric conditions in the seed house allowed only a very slow rate of conditioning. Aeration was therefore resorted to as frequently as was practicable—at least once daily—by turning the seed thoroughly.

Obviously numerous moisture estimations had to be made from time to time, during the conditioning period, in respect of the seeds of all the grass strains bred at the Station. It is generally considered that the senses of touch and smell (8) are not sufficiently reliable for indicating the approximate content of moisture. Several mechanical methods have been devised for making rapid determinations of moisture and the Davies Moisture Meter described in the current volume of this Journal (16), has been found to be extremely useful and reliable for the purpose. This instrument has been used, with a considerable degree of success, for several years at the Welsh Plant Breeding Station.

It was not found necessary to make frequent moisture tests on obviously damp seeds during wet weather, nor when the atmosphere in the seed house was humid. The norms were reached only very slowly, when the atmospheric conditions exceeded about 80 per cent. humidity at 60° F. Under average favourable conditions, seeds of rye-grass, cocksfoot and timothy, with initial moisture contents ranging from 15.0 to 20.6 per cent., lost their excess moisture in two to eight days when the seeds were spread out in bins to a depth of 12 inches and turned daily. Isolated days with favourable atmospheric conditions helped to speed up the rate of drying, and, in general, numerous observations indicated that the higher the initial moisture content, the greater the rate of evaporation under favourable conditions. On the other hand, under unfavourable conditions, the lower the moisture content the greater the rate of absorption.

In 1937, the atmospheric conditions both in the field and in the storehouse favoured rapid removal of excess moisture from the seeds; and often newly threshed lots contained 1 to 2 per cent. moisture below the norm. Conditioning was comparatively rapid, and seed lots with the lowest moisture contents did not even require conditioning, and were thus stored in bags immediately after threshing.

It was found that when the initial moisture content was about 15 per cent., or when the moisture had reached this value, one to two days under favourable conditions was sufficient for drying them down to safety limits. As soon as the moisture content had been reduced to the norm, or had passed below it, the seeds were bagged as quickly as possible; data, set out in Table VI, indicate clearly that there is less variation in the moisture content of seeds which are packed in bags at or below their norms, than in that of similar seeds left in bins.

During the experimental period of 14 days the average range in moisture of the bagged seeds was 0.4 per cent., whilst that

TABLE VI.

Showing the daily variations in the moisture content of seeds of rye-grass, cocksfoot and timothy, (a) stored in bags, (b) left in bins.

Days	*Perennial rye-grass* (a) *Bag*		(b) *Bin*		*Cocksfoot.* (a) *Bag*		(b) *Bin*		*Timothy.* (a) *Bag*		(b) *Bin*		*Per cent. humidity Approx.*
	Per cent.	*S.E.* ±	*Per cent.*	*S.E.* ±	*Per cent.*	*S.E.* ±	*Per cent.*	*S.E.* ±	*Per cent.*	*S.E.* ±	*Per cent.*	*S.E.* ±	
Initial.	14.0	.03	14.0	.03	13.1	.01	13.1	.01	13.6	.03	13.6	.03	85
1st day ..	14.0	.03	14.1	.02	13.1	.02	13.1	.01	13.6	.04	13.6	.02	80
2nd day ..	14.0	.03	14.0	03	13.1	.01	13.1	.03	13.6	.01	13.7	.03	80
3rd day ...	13.9	.03	13.8	.04	13.2	.01	13.0	.01	13.5	.02	13.3	.01	75
4th day ...	13.8	.03	13.6	.03	13.1	.04	12.8	.01	13.4	.03	13.1	.01	75
5th day ...	13.8	.03	13.5	.01	13.0	.01	12.6	.01	13.1	.02	12.9	.01	80
6th day ..	14.0	.02	13.9	.05	13.0	03	12.6	.01	13.1	.01	13.1	.03	85
7th day ..	14.1	.03	14.2	.03	12.9	02	13.0	.02	13.2	.01	13.4	.04	90
8th day ...	14.2	.02	14.4	.01	13.0	.04	13.1	.01	13.3	.01	13.6	.01	90
9th day ...	14.2	.04	14.5	.02	13.1	.01	13.3	.02	13.3	.01	13.7	.02	90
10th day ...	14.0	.03	14.6	.03	13.2	.03	13.5	.03	13.4	.03	13.9	.03	90
11th day ...	14.1	.03	14.3	.02	13.2	.01	13.4	.01	13.4	.01	13.8	.04	75
12th day ...	14.0	.01	14.3	.01	13.0	.01	13.2	.02	13.3	.02	13.6	.05	80
13th day ...	14.0	.03	14.2	.03	12.8	.01	13.1	.01	13.5	.05	13.6	.04	80
14th day ...	14.0	.03	14.1	.01	12.8	.01	13.2	.01	13.5	.01	13.5	.01	
Mean ...	14.0		14.1		13.0		13.1		13.4		13.4		
S.E. ± ...	0.03		0.07		0.03		0.06		0.04		0.07		

S.E. of means indicate greater variation in bins than in bags.

of the seeds in the bins was about 1.0 per cent. It will be noticed too, on reference to Table VI, that the moisture changes of seeds in the bins may be correlated with the humidity of the atmosphere during the previous 24 hours. The data in this Table support the inference that the norms for the seeds of the grass species concerned are maintained in atmospheres of about 80 per cent.

It may be concluded from these results that if seeds which have had their excess moisture removed be allowed to remain in the bin, unfavourable atmospheric conditions might set in and influence the moisture of the seeds adversely, whereas such unfavourable conditions would not have a correspondingly adverse effect on bagged seeds.

Numerous observations during periods of changeable atmospheric conditions indicate that, in the case of seeds which were drying rapidly, if a damp period set in and tended to increase the moisture content, heaping the seed after aeration largely prevented reabsorption of moisture. This was particularly noticeable if the moisture was only slightly in excess of the norm. Such seed would reach a satisfactory condition very rapidly if spread out again on the advent of dry weather.

Dorph-Petersen (8), and others, stress the advisability of cleaning seeds before storage. The chief impurities in newly harvested seed lots of rye-grass, cocksfoot and timothy are leaves and straw of the seed crops themselves, and leaves, stems and seeds of miscellaneous weeds. In rye-grass seed may be found considerable quantities of clover leaves and unhulled seeds.

At the Welsh Plant Breeding Station winnowing has been found to rid seed lots of large amounts of hygroscopic material, resulting in a lower moisture content. A sample of rye-grass (S. 23) seeds of 79 per cent purity and containing 16.1 per cent. moisture was winnowed quickly, and then sieved to get rid of the heavier leaf and straw. The process took about 30 minutes, at the end of which time the moisture content of the cleaned seeds was 14.9 per cent. and that of the impurities was 21.3 per cent. The reduction in moisture might have been due in part to the winnowing process, but the resulting clean seeds dried more rapidly than an uncleaned sample when both were put into adjacent bins for comparative study. Figure I shows the daily changes in the moisture contents of the two lots in relation to atmospheric humidity and temperature.

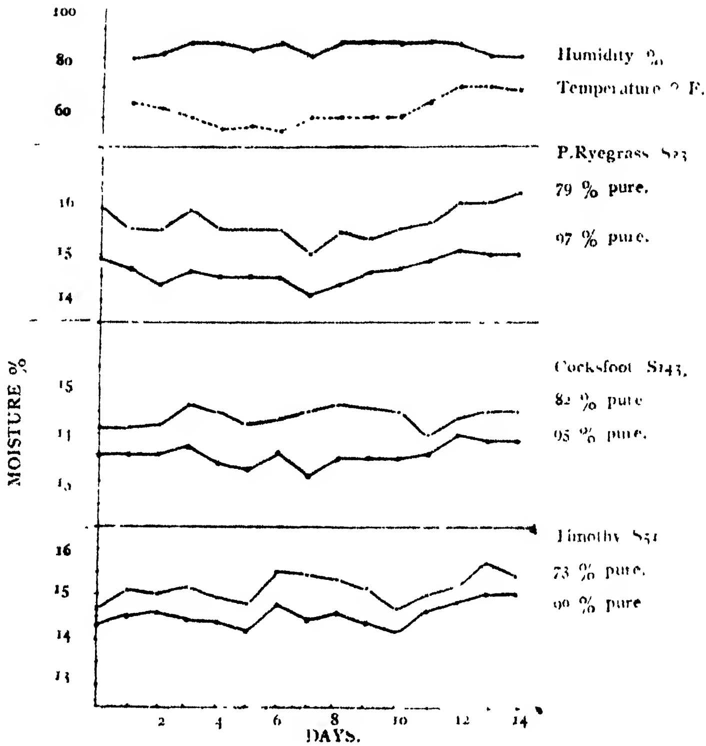

FIG. 1.

Showing the comparative changes in moisture content of seeds of perennial rye-grass, cocksfoot and timothy in relation to degree of purity and atmospheric conditions.

Also shown in Figure 1 are similar results which were obtained using cocksfoot and timothy seeds. These results emphasize the advisability of removing hygroscopic material, if the seeds are to be dried as quickly as possible under natural conditions. It is evident that one of the advantages of cleaning seed bulks containing relatively high percentages of impurities, is to reduce the moisture of the bulk, (1) by getting rid of the highly hygroscopic impurities, and, (2) by aeration in the winnower.

Table VII shows the comparative rates of drying of rye-grass, cocksfoot and timothy seeds, with the same initial moisture contents, under the same conditions.

The data in this table are the averages of numerous observations made in 1936, and other data obtained on other occasions in 1936 and in 1937 support the conclusions drawn from these results; namely, that cocksfoot seeds dry more quickly

TABLE VII.

Showing the comparative rates of drying of seeds of rye-grass, cocksfoot and timothy with the same initial moisture content.

Days.	*Perennial rye-grass*		*Cocksfoot*		*Timothy*		*Humidity.*	*Temperature ° F.*
	Moisture Per cent.	*S.E.* ±	*Moisture Per cent.*	*S.E.* ±	*Moisture Per cent.*	*S.E.* ±		
1	15.5	.02	15.5	.03	15.5	.04	95	63
2	15.4	.03	15.1	.01	15.4	.03	80	60
3	14.8	.01	14.5	.04	14.9	.04	85	62
4	14.3	.02	14.0	.01	14.4	.02	80	58
5	14.0	.01	13.6	.01	13.8	.03	80	61
6	14.0	.02	13.3	.02	13.6	.03	75	63
7	13.8	.01	12.9	.02	13.5	.01	80	64
8	14.0	.02	13.1	.01	13.6	.02		

than those of rye-grass, timothy seeds taking an intermediate position. Under the same conditions of humidity and temperature, perennial rye-grass seeds contain more moisture than timothy and cocksfoot; *e.g.* under conditions of about 80 per cent. humidity at 60° F. the equilibrium moisture contents of the seeds of these grasses are 14.0, 13.6 and 13.0 per cent. respectively. It will be observed also that these values are precisely the figures previously established as norms for these species, which is highly significant.

Dorph-Petersen (8) suggests that if the storehouse has several rooms of different humidities, the damper seeds should be conditioned in the least humid ones. In the event of the relatively dry rooms being used for rye-grass and cocksfoot seeds, when moister seeds are brought in for conditioning, it is claimed by Dorph-Petersen that the rye-grass and cocksfoot will suffer very little if transferred to the more humid rooms. Care must be taken, however, to maintain good ventilation in the more humid rooms. Experimental evidence, obtained by the writer in 1936, indicated that seeds of rye-grass, cocksfoot and timothy tended to lose moisture more rapidly than they absorbed it. Cocksfoot had the lowest and rye-grass the highest rate of absorption.

In brief, the results of the investigations in connection with the conditioning of newly harvested seeds of rye-grass, cocksfoot and timothy indicate that although great care must be

exercised in handling the seeds, those of perennial rye-grass, owing to their relatively high rate of absorption and low rate of drying, and to a lesser extent those of timothy, need more careful attention than cocksfoot seeds.

Seeds should be spread out as thinly as possible on floors or in bins in well ventilated seed houses, frequent aeration being essential. On damp days, all doors and windows should be shut, and it is suggested that seeds in the bins be heaped up, to be spread out again on dry days. As soon as the norms are reached, the seeds should be bagged and the bags then stored in airy positions, especially if the humidity of the atmosphere tends to be high.

Artificial Drying.

In recent years the increasing use made of mechanized methods of harvesting has emphasized the need for rapid methods of drying seeds. Drying plants for grain have already become standard equipment wherever harvester-combines operate. The seeds of the mature crop after being threshed on the field are passed through the drier to bring their moisture content down to or below the norm. Obviously a great deal of skill is required to attain the desired conditions in the seeds for storing without injuring the viability in the drying process. Here the grower requires very exact information in dealing with seeds to avoid costly errors.

The results obtained by Stapledon and Adams (15) led them to conclude that in wet districts, and especially after bad seasons, the drying of wheat, barley and rye grains immediately after threshing and before storage would be a considerable advantage to farmers, since the chances are in favour of increased germination as a result of careful drying.

Artificially dried seeds have been found to possess a high degree of germinative energy, and it has been demonstrated by repeated trials that kiln-dried seeds produce more vigorous crops than those left without treatment throughout the winter. Drying has also been found to secure a more even germination in the case of many other economic crops.

The obvious methods of hastening the removal of excess moisture from seeds involve the effects of air movements and heat.

Dillman (6) and others have emphasized the need for speeding up the rate of evaporation of hygroscopic moisture from damp seeds by subjecting them to a current of air.

That the temperature which seeds can tolerate varies from one species to another has been demonstrated by the investigations of Hottes and Wilson (11), Atanasoff and Johnson (1), and Dixon (7), among others. The resistance of seed viability to heat is inversely proportional to the initial moisture content.

The most important point to be borne in mind in the management of seed driers is therefore the avoidance of very high temperatures.

Newman and Blackaby (14) describe trials with a combine harvester-thresher in Wiltshire in 1928 and the grain drier used by them delivered a current of hot air to barley grain at 137° F. The initial moisture content of about 20 per cent. was reduced by this hot air current to about 15 per cent. in one hour. Tests showed that the germination was not in any way impaired. After subjecting the grain to hot air drying, a current of cold air was passed through it to cool before bagging, and in its passage through the hot grain the cold air became warmed and took up moisture from the surface of the grain.

Preliminary investigations along these lines were conducted by the writer at the Welsh Plant Breeding Station in connection with the artificial drying of grass seeds, and although these investigations were limited in scope, the results indicate possibilities in seed drying.

The seeds used for the artificial drying experiments were :

	Per cent. Purity	Per cent. Initial moisture.
Perennial rye-grass S. 23 .	91	18.3
Perennial rye-grass S 101 ..	99	17.6
Cocksfoot S. 143	98	16.1
Cocksfoot S. 26	89	17.8

About four days after threshing, samples of these seeds were subjected to drying by a current of hot air, alternating with one of cold air, both of low humidity. The hot air current was passed through the seeds at 95°, 104°, 110°, 120°, 130°, 140°, and 154° Fahrenheit, and the humidity of the air before entering the seed chamber was about 45 per cent. The air-current was of sufficient pressure to keep the seeds moving in the seed chamber.

The seeds were dried to their norms by subjecting them to alternating hot and cold air currents, in the proportion of 20 minutes by heated air followed by 10 minutes in cold air (60° to 65° F.). The object of the alternating cold air current is twofold : firstly, to counteract the *possible* adverse effect of the heat

on the seeds themselves, and, secondly, to cool the seeds quickly, at the same time preventing the reabsorption of vapourized moisture. It was found, as the result of drying by a continuously hot air current until the excess moisture had been removed, that the germinability of the seeds was adversely affected, even when the temperature was no higher than 95° F. It was thus decided to make further experiments introducing the cold air current into the process.

The moisture content was determined every half hour, *i.e.* after being cooled for 10 minutes by cold air.

After the excess moisture had been removed from the seeds, samples of each lot, dried under different conditions, were put up for germination. Tests were also made of these and untreated lots after about three months' storage in bags under favourable seed house conditions.

The results of these experiments are set out in Table VIII.

The data in Table VIII indicate several effects of the application of a current of hot air, alternating with a cold one, for drying seeds of perennial rye-grass and cocksfoot Drying by a current of hot air above about 110° F. apparently had a detrimental effect on the immediate and subsequent germination of the seeds of both grasses whose initial moisture contents were at least 17.6 and 16.1 per cent., respectively. About 104° F. appeared to be the optimum for drying off the excess moisture.

TABLE VIII.

To show the effect on Germination Energy (GE) and Germination Capacity (GC) of drying by alternating hot and cold air currents.

(i) Perennial rye-grass S 101.

(*a*) Initial moisture content = 17.6 % (GE = 65.2 % ± 1.3). (GC = 94.8 % ± 1.8).

(*b*) After natural drying to 14 % moisture (GE = 67.3 % ± 2.0). (GC = 94.1 % ± 1.5).

(*c*) After natural drying and 3 months' storage (GE = 70.0 % ± 0.0). [illegible] 93.9 % ± 0.9)

Dried to 14 per cent. at ° F	*Drying time, hours.*	*Germination %*							
		Immediately after drying.				*After drying and storing for three months.*			
		GE	SE	GC	SE	GE	SE	GC	SE
			±		±		±		±
95 °	2--2½	61.2	0.9	97.2	0.7	72.0	1.0	100	0.0
104 °	2	65.3	0.9	99.1	0.2	72.9	0.5	100	0.0
110 °	2	63.9	0.8	93.2	0.9	62.1	1.6	96.1	0.7
120 °	1½	62.7	1.6	87.3	1.8	62.0	1.0	90.1	2.1
130 °	1	51.8	1.9	79.1	1.1	49.7	2.3	82.5	1.3
140 °	½	35.9	2.3	59.8	1.9	52.6	1.9	56.1	1.9
154 °	½	42.3	1.7	61.4	2.0	29.7	4.3	56.0	2.1

(ii) Perennial rye-grass S. 23.

(*a*) Initial moisture content = 18.3 %	(GE = 72.9 % ± 1.8).
	(GC = 95.7 % ± 2.1).
(*b*) After natural drying to 14 % moisture	(GE = 72.9 % ± 1.8).
	(GC = 95.1 % ± 1.0).
(*c*) After natural drying and 3 months' storage	(GE = 77.6 % ± 1.5).
	(GC = 96.0 % ± 0.0).

Dried to 14 per cent. at ° F	*Drying time, hours.*	*Germination %* *Immediately after drying.* GE	SE ±	GC	SE ±	*After drying and storing for three months.* GE	SE ±	GC	SE ±
95 °	3½	74.0	0.3	96.3	0.9	89.3	0.1	100	0.0
104 °	3	75.6	0.7	99.8	0.1	90.7	0.1	100	0.0
110 °	2½—3	70.9	1.5	98.2	0.3	82.0	0.9	100	0.0
120 °	2	71.3	2.4	90.3	2.1	63.4	4.6	91.0	2.7
130 °	1½	40.7	2.7	73.0	1.1	20.7	6.9	50.3	2.5
140 °	1	51.8	1.9	63.0	1.0	40.1	2.7	63.1	1.1
154 °	¼—1	28.6	4.8	39.7	2.3	33.3	3.7	48.0	5.0

(iii) Cocksfoot S. 142.

(*a*) Initial moisture content = 16.1 %.	(GE = 70.3 % ± 1.1).
	(GC = 97.9 % ± 0.9).
(*b*) After natural drying to 13 % moisture	(GE = 69.9 % ± 1.0).
	(GC = 98.0 % ± 1.8).
(*c*) After natural drying and 3 months' storage	(GE = 70.0 % ± 2.0).
	(GC = 96.3 % ± 1.7).

Dried to 13 per cent. at ° F	*Drying time, hours.*	*Germination %* *Immediately after drying.* GE	SE ±	GC	SE ±	*After drying and storing for three months.* GE	SE ±	GC	SE ±
95 °	1½—2	70.4	1.0	92.1	0.7	80.4	0.2	100	0.0
104 °	1½	68.9	0.9	95.7	0.8	91.1	0.3	100	0.0
110 °	1 —1½	70.0	2.1	96.0	0.0	91.0	0.9	100	0.0
120 °	1	65.2	3.1	92.4	2.1	70.8	0.3	98.3	0.8
130 °	½—1	37.8	4.6	81.4	1.5	13.5	6.0	71.0	6.2
140 °	½	49.1	0.9	71.1	1.9	52.8	0.9	68.3	2.4
154 °	½	27.2	6.2	44.3	0.6	11.6	2.1	37.1	1.9

(iv) Cocksfoot S. 26.

(*a*) Initial moisture content = 17.8 %	(GE = 44.5 % ± 3.5).
	(GC = 88.7 % ± 2.1).
(*b*) After natural drying to 13 % moisture	(GE = 63.5 % ± 1.5).
	(GC = 90.2 % ± 1.0).
(*c*) After drying and 3 months' storage	(GE = 71.0 % ± 0.9).
	(GC = 93.0 % ± 0.0).

Dried to 13 per cent. at ° F	*Drying time, hours.*	*Germination %* *Immediately after drying.* GE	SE ±	GC	SE ±	*After drying and storing for three months.* GE	SE ±	GC	SE ±
95 °	2½	71.9	2.1	95.3	1.5	89.3	0.7	100	0.0
104 °	2	65.7	1.3	98.7	0.7	90.0	0.0	100	0.0
110 °	1½—2	70.3	1.9	99.1	0.2	89.7	0.5	99.8	0.1
120 °	1½	71.5	0.8	82.5	0.5	71.5	0.3	81.6	0.8
130 °	1	29.0	3.0	67.8	1.6	47.2	3.5	70.5	1.5
140 °	½—1	41.5	1.5	46.0	2.3	44.0	1.9	54.3	1.1
154 °	½	37.0	1.1	51.8	4.1	31.4	1.9	42.1	2.7

when the initial moisture contents were as high as 18.8 per cent. in rye-grass and 17.8 per cent. in cocksfoot.

The use of relatively low temperatures ranging from 95° to 110° F. resulted in an improved germination capacity, which was, however, not immediately noticeable; but 100 per cent. germination was obtained in all seed lots dried at these temperatures tested after three months' storage under favourable conditions.

Drying at these favourable temperatures and storing for three months resulted in an increased germination energy : an increase of up to 18 per cent. in ryegrass, and up to about 22 per cent. in cocksfoot. Germination of an even character was secured as a result of drying at 95° to 110° F., but this effect—as indicated by the low Standard Error (SE) values—was more pronounced after storage, although naturally conditioned seeds after storage showed an even germination in all lots except that of cocksfoot S. 143.

It may be concluded from this brief survey of the investigations relating to artificial drying, that hastened removal of the excess moisture from newly threshed seeds of perennial rye-grass and cocksfoot favours improved germination energy and capacity, and evenness of germination, particularly after a period of storage.

Summary and Conclusions.

It is apparent from the results of the investigations reported in this paper that the successful grower and seed producer must needs pay careful attention to the moisture content of newly threshed seeds.

(1). It is advisable to remove excess moisture from the seeds as quickly as possible. Excess moisture is that moisture which is present in excess of the norm. This norm has been established as being about 14.0 per cent. for rye-grass, 13.6 per cent. for timothy, and 13.0 per cent. for cocksfoot.

(2). Bagging the seeds with moisture contents above the norms suggested has a detrimental effect on the seeds during storage; they become heated, develop moulds, are inclined to sprout, and their germinability is greatly impaired.

(3). Once the norm has been reached, it is advisable to bag the seeds as quickly as possible, since adverse atmospheric conditions which might set in do not have such a marked effect on bagged seeds as on similar seeds left in bins.

(4). Owing to the greater rate of absorption and slower rate

of drying, seeds of perennial rye-grass require more careful attention during conditioning than those of cocksfoot or timothy.

(5). The removal of excess moisture artificially by heat has much to recommend it. A current of hot air, at a temperature of not more than 110° F., alternating with a cold one, is particularly efficacious in removing excess moisture from seeds of rye-grass and cocksfoot, about 4.5 per cent. being removed in 1½ to 2 hours. Germination energy and capacity, and evenness of germination are favourably influenced by artificial drying; this effect is particularly noticeable after a period of storage.

(6). Storage, after drying, must be considered as an important factor in the retention of viability, and a well ventilated storehouse is essential if the atmosphere tends to have a humidity of 80 per cent or over. At this humidity, and an average temperature of 60° F, the seeds maintain their norms. In any event, a low temperature, the lower the better, should be aimed at, and if the atmosphere is dry (below 80 per cent. humidity), sealed (air-tight) rooms are considered conducive to the maintenance of viability. It is suggested that it would be worth while storing irreplaceable stock seeds in sealed containers after reducing the moisture content to a low value by artificial drying.

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THE RAPID DETERMINATION OF MOISTURE CONTENT IN GRASS SEEDS.

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Introduction.

The problem of moisture content in seeds is having wider recognition as its bearing on the viability, vigour and longevity of seed is more fully appreciated. It is a problem of which the seed grower as well as the seed merchant must take proper cognizance in areas where the growing of grass seeds is established as a new branch of husbandry, for no other factor has greater influence in determining the quality of seed *qua* seed

than moisture content during harvest and after threshing. Excessive moisture in threshed seed can lead to serious harm to the seeds, to viability as measured by laboratory tests, and still more to the power of establishment under ordinary field conditions.

There has been a tendency in Britain during recent years to thresh seed crops of improved strains of grasses immediately they are carted from the field, or soon afterwards. According to the older practice either the grass seed crops are left in stooks or rickles for a considerable time in the field, or they are stored in bays for some time before threshing, as is commonly done with clover seed crops. Managed in this manner the seed crops do not usually contain a sufficiently high moisture content to cause serious damage, and yet there is always the risk that they will not exhibit the characteristics of high quality seed. There is the attendant risk of weather damage to crops left on the field for considerable periods, apart from heat and moulds that may develop after such crops are brought under cover.

Several considerations have been responsible for the tendency to thresh grass seed crops within a short time of harvesting. Many areas exist in England and Wales where conditions are often very favourable to the rapid drying of harvested crops on the field, and in such districts opportunities frequently occur to thresh the seed crops in the open. A further encouragement to this practice is the difficult problem of labour which compels growers to handle such crops as little as possible.

The characteristic leafiness of bred strains of grasses may cause the seed crops, unless favoured by proper management and season, to be somewhat more difficult to dry on the field than crops of ordinary strains, and this constitutes a further inducement to thresh the crops from off the field. Grass seeds thus garnered fresh from the field and threshed must of necessity be carefully handled and properly conditioned if there is reason for believing that the moisture content is excessive. Weather vagaries may be such, in some seasons, that growers find it necessary to thresh the grass crops when the moisture content of the seeds is upwards of 20 per cent., in which case measures must be taken immediately to reduce the contained moisture to a level at which the seeds may be safely bagged. Above this the seeds are likely to deteriorate slowly or rapidly, according to the conditions under which they are stored.

Excess moisture can be removed from grass seeds under

ordinary atmospheric conditions by having them spread out on airy barn floors and turned frequently. The seed of each grass species has probably its own specific norm,[1] as indicated by Williams (2), such norms being taken to mean a moisture content beyond which seeds may easily be damaged in storage. These norms for different grasses cannot with any precision be determined merely by handling the seeds, and the grower may be faced with the alternative of either risking the viability of the seed by premature sacking or, in order to make certain of the seed quality, of continuing to turn it for some days after the moisture has been reduced sufficiently. This empirical method of estimating the condition of the seed proves particularly inadequate where the problem of floor space is an acute one, owing to the necessity for drying various seeds in succession and storing them.

Latterly with the advent of the combine harvester it is possible to thresh standing crops of some species of grasses, and artificially drying them by modern plants solves the problem of conditioning the seed. The user of an artificial drying plant in conjunction with a small combine has to rely continually on empirical methods of determining the moisture content of grass seeds at different stages of conditioning.

The need for a simple, rapid and reliable apparatus for determining moisture content in grass seeds had been apparent for some time when Dr. R. M. Davies in conjunction with the Welsh Plant Breeding Station constructed his Moisture Meter.[2] This paper is concerned with the calibration of the Davies Moisture Meter in relation to rye grass, cocksfoot and timothy seeds.

The Davies Moisture Meter

(1) *Description.* Electrical and non-electrical methods for determining the moisture content of seeds have been extant for some time. These methods are discussed fully by Davies (1), who demonstrates their inadequacy for dealing with the peculiar texture of grass seeds. Davies discusses electrical methods of his own device to meet the requirements of grass seeds, and finally describes in detail an instrument of his own construction which we propose calling the Davies Moisture Meter.

[1] See Appendix

[2] Now obtainable from Messrs. Robinson Nelson and Co., Ltd., Faraday House, Sale, Cheshire

THE DAVIES MOISTURE METER.

Fig. 1.

A. Seed Vessel. B. Plunger

C. Cylinder for receiving A. D. Galvanometer scale.

E. Switch (turned to "Standard.") F. Zero adjuster

G. Dry battery.

The Davies Moisture Meter is designed to determine, accurately and within a few minutes, whether the moisture content of grass seeds has reached the norm at which they can be stored in sacks with safety. It is constructed in such a manner that for practical purposes it can be used successfully by store men possessing no high degree of skill.

Essentially the Moisture Meter consists of a seed vessel (Fig. 1.A) in the form of a brass cylinder, one end of which is closed by an ebonite disc into which is fitted a brass plug by means of a brass screw. This seed vessel, or cylinder, slides into another similar brass cylinder (C), the brass plug fitting into a brass cup at its base. This second cylinder is part of an electric circuit.

A sample of the seed to be tested is packed as tightly as possible into the seed vessel by means of a lead plunger fixed to an ebonite cylinder (B). The electric current is supplied by an ordinary high tension dry battery (G) with which is usually associated a small grid bias battery for the purpose of adjusting the voltage to the constant value required to operate in the circuit. A galvanometer interpolated in the circuit measures the resistance to the current passing through the seed, the greater the moisture content the lower the resistance, and the higher the galvanometer reading. The Moisture Meter is shown in Fig. 1.

(2) *Operation.* The procedure recommended by Davies for operating the Moisture Meter is as follows.

(i) The standard voltage for testing the moisture content of seeds is checked by turning switch (E)—Fig. 1—to the right-hand position (marked "standard" on panel), the galvanometer being arranged to function as a voltmeter, (the standard voltage for these tests is 39 to 41 volts). The switch is then turned to the neutral position (marked "off").

(ii) The seed vessel (A) is packed with seeds as described above, and inserted in the machine.

(iii) The current is introduced into the circuit by turning the switch to the left-hand position (marked "on"), and when the galvanometer needle has become steady the reading is taken from the scale.

(iv) The moisture content of the sample is found by reference to the appropriate calibration table in which moisture content is set against each degree of the galvanometer deflection.

(v) On removing the tested sample of seed from the cylinder, care must be taken to avoid mixing it with the rest

of the samples to be tested, and the cylinder requires to be wiped with a clean, soft, dry cloth.

Calibration.

The instrument was calibrated by Davies in the first instance for dealing with timothy (*Phleum pratense*) seeds and, although it was said to give satisfactory results with the seeds of cocksfoot and other grass species, only one calibration chart, that for timothy, was published.

On account of the wide variation in the texture and packing properties of seeds of different grass species it was considered necessary to establish calibration curves for grass species other than timothy. In the course of the investigations reported in this paper calibration curves for seeds of the three most important grass species bred by the Welsh Plant Breeding Station, namely, perennial rye-grass (*Lolium perenne*), cocksfoot (*Dactylis glomerata*) and timothy were prepared by one of the authors of this paper. Certain observations made during calibration led to the revision of the original timothy curve constructed by Davies.

(1) *Material.* All the seeds used were derived from strains bred at Aberystwyth and grown in the border counties of Wales and England during the season in which the tests were made. It was considered desirable to include the seeds of more than one strain of each species in order to see how far varietal differences influenced the form of the calibration curves. Details of the seeds used to construct the calibration curves in this paper are given in Table 1.

TABLE I.

Showing details of grass seeds used to construct calibration curves.

Species.	*Type.*	*Strain No.*	*Percentage.* Purity.	*Percentage.* Initial moisture.
A. Perennial rye-grass	Pasture.	S. 23	100.0	17.5
B. ,,	Pasture-hay	S. 101	92.3	18.7
C. Cocksfoot	Pasture	S. 142	91.0	20.7
D. ,,	Pooled strains	—	100.0	16.4
E. Timothy	Pasture	S. 50	89.7	17.6
F. ,,	Pasture-hay	S. 48	98.0	19.2

In order that the results obtained from these investigations should have the greatest practical value the seed samples were

drawn from freshly threshed crops when the moisture content was naturally higher than the safety norms[1] for various types of grass seeds. The moisture in these samples ranged between 16 and 21 per cent. (Table 1); these figures representing the condition of most crops during the relatively wet season of 1936.

Samples B, C and E in Table 1 were drawn directly from bulk seeds as they came from the thresher without further cleaning, beyond removing occasional gross pieces of straw or leaf. Only negligible quantities of impurities were included in these seeds besides empty glumes and chaff. The samples A, D and F had been dressed free from all, or nearly all, impurities.

(2) *Method.* Approximately 5 lb. of a particular seed lot was thoroughly mixed in a galvanized iron tray (30 inches x 15 inches). Random pinches (= small amounts held between thumb and index finger) of the seeds were packed into the seed cylinder, and, following adjustment of the cylinder in the machine, a galvanometer reading was made. Five replications were made in this manner, and the mean deflection of the five samples calculated.

Five random samples, each about 10 gm. (to the nearest milligram) of the seeds in the tray were weighed into small glass dishes (5.5 cm. diam. x 3 cm. depth) of known weight. The seeds were dried to a constant weight in a water oven at 99.3° C. in the course of from twelve to fifteen hours, during which a glass rod was used to mix the seed from time to time. By taking the mean of the five replicates it was possible to calculate the average moisture content of the seeds at the time the galvanometer readings were taken.

It was found that the initial galvanometer deflections for these seeds were in the neighbourhood of fifty, and it was then sought to establish the moisture equivalents of galvanometer deflections ranging from fifty down to one. To this end the seeds in the tray were turned and mixed frequently and galvanometer deflections and their moisture equivalents determined at intervals as the seeds dried in the atmosphere of the laboratory. Calibrations were thus made for each of the three species named by taking readings for every unit deflection from one to ten, every two from ten to twenty, and at irregular intervals from twenty to fifty.

(3) *Results.* A minimum of three sets of replicated moisture tests were made for each of the deflection values chosen, and

[1] See Appendix.

the results of these tests are set out in Fig. 2. Two theoretical curves (broken lines) and the mean curve (continuous line) are

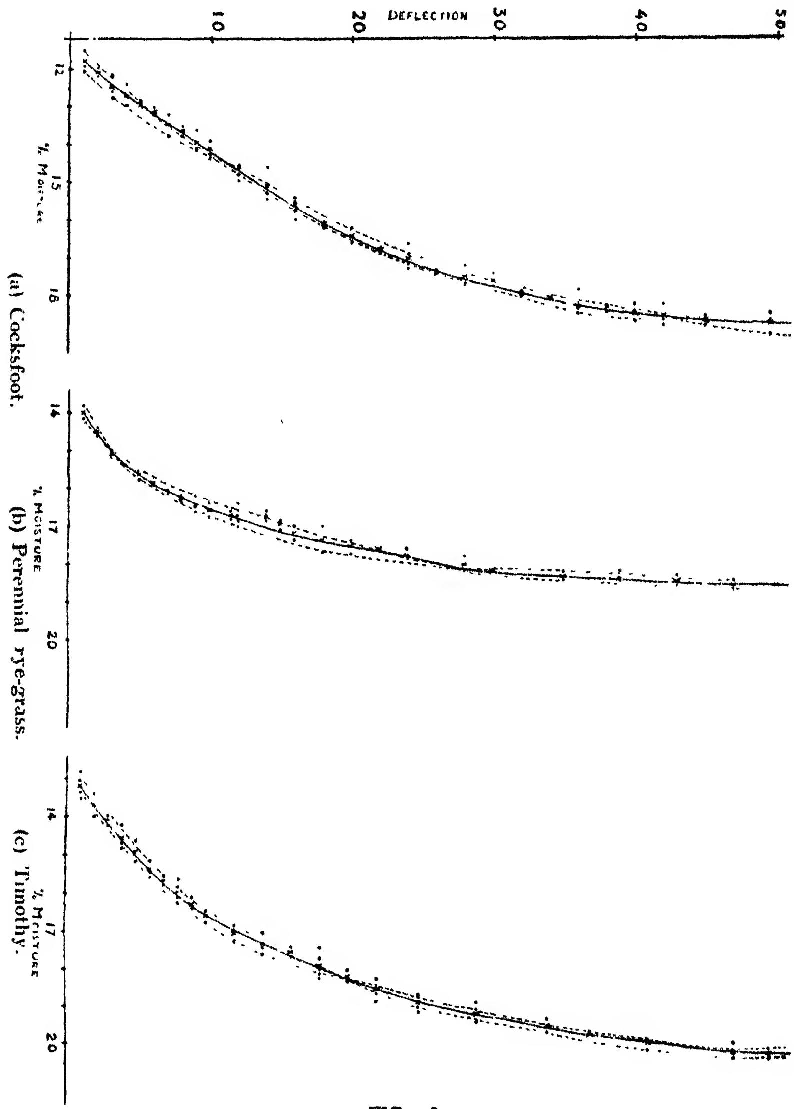

FIG. 2.

Curves of calibration.

. - . theoretical curves

x —— —x mean curve.

plotted for each species, and it will be seen that the configuration of each set of specific curves corresponds fairly closely. Statistical

analyses of the data indicated that the differences between the readings within the species are not significant, the values for P. ranging between 0.05 and 0.20. Thus for practical purposes the mean curves may be taken to represent the required calibrations.

A comparison of the mean curve for the three species is shown in Fig. 3. Davies's timothy curve is also represented in Fig. 3.

A study of these curves shows that the three new curves exhibit similar general trends; at the same time each possesses a distinct individuality. This feature is of considerable interest and significance in relation to the electrical methods of determining the moisture content of different species. It has been pointed out, on the other hand, that in the material investigated the differences obtaining between species did not extend to strains; in fact the curves for one strain could be superimposed almost exactly on the curve for another strain of the same species, although the percentage purity was different for each strain within the species.

Of the four curves shown in Fig. 3, the one produced originally by Davies for timothy seeds diverges considerably from the general trend of the others at the higher deflection values. The new timothy curve follows closely the Davies curve up to a deflection of ten, but thereafter it becomes steeper and tends to flatten out.

Whereas there is a rough parallelism between the new timothy and the cocksfoot curves, the curve for perennial rye-grass crosses the other two rather curiously.

Discussion of Results.

The divergence between the original curve for timothy and the new one can be explained by the fact that the latter was constructed by using recently threshed seed which was allowed to dry naturally to obtain statistics for establishing the curve, while, on the other hand, the former was constructed by using rather old and dry seeds which had to be artificially damped. It will be noted in Fig. 3 that a relatively small increase in percentage moisture of seeds, moistened artificially, alters the character of the curve. After investigating this phenomenon further it was found that by artificially moistening nine months old seed with water a curve following Davies's curve closely the whole length could be constructed for timothy, and a curve showing a similar tendency was obtained for cocksfoot (Fig. 4).

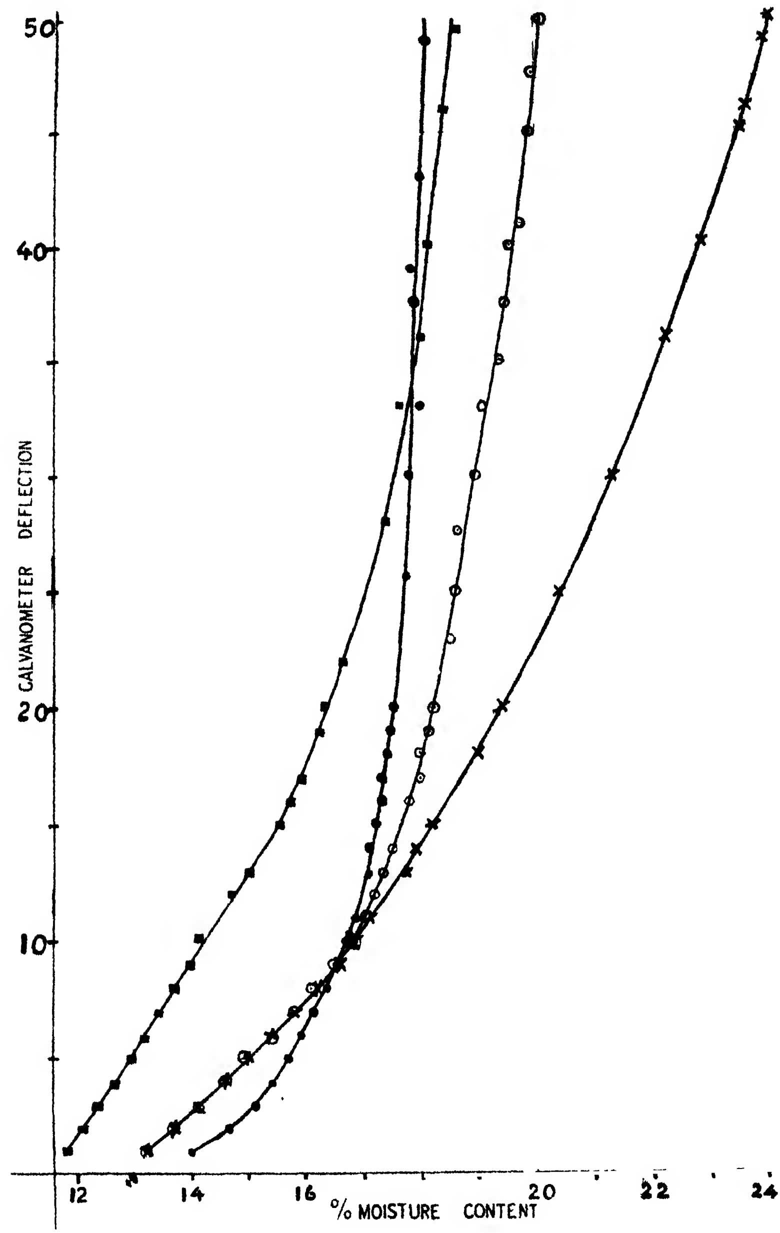

FIG. 3

Mean curves of calibration.

■ Cocksfoot.
● Perennial rye-grass.
⊙ Timothy.
x Davies's timothy curve.

It was further proved that the seeds of freshly harvested crops, when water was added directly to moisten them artificially, produced curves conforming almost exactly to those obtained when using naturally moist seeds of the same crops. Added water has thus a distinctly different effect on the electrical conductivity

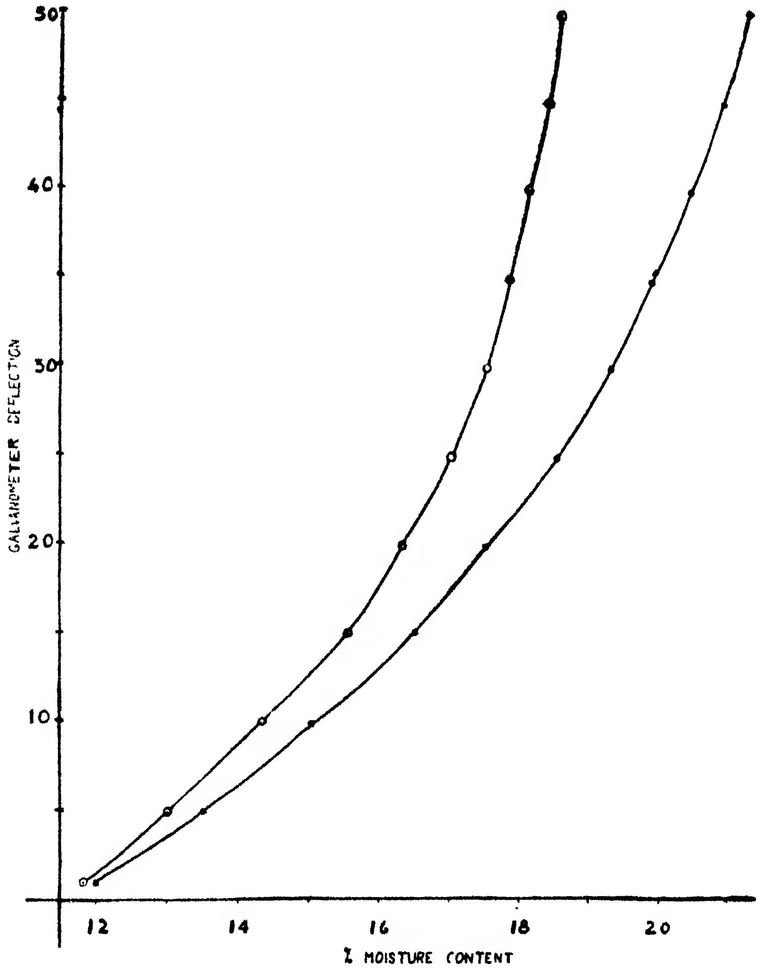

FIG. 4.

Mean curves of calibration for seeds of cocksfoot.

⊙ Newly-harvested.

● At least nine months after harvesting

of young seeds compared with seeds which have been kept under storage conditions for a considerable time. The significance of this is that separate curves or calibration tables must be provided for determining the moisture content of seeds which have been

dried down to the norm, or below, for a considerable period, and then moistened by design or otherwise. In practice, however, the curves and tables constructed for freshly harvested seeds are expected to be made use of more generally than any others.

The distinct individuality of the curves for freshly threshed cocksfoot, timothy and rye-grass seeds suggests that characteristic curves are likely to be produced from the reactions of the seeds of other species of grasses.

That the curves are specific for each grass is supported by the fact that the electrical conductivity is very similar for different strains within a species at different levels of moisture content.

Along the whole range of deflection readings in Fig. 8 the seeds of timothy strains have a higher moisture content than cocksfoot strains. The seeds of perennial rye-grass, on the other hand, are significantly moister than those of either cocksfoot or timothy at the same deflections from one to nine, and drier than the seeds of those two species at equivalent deflections beyond thirty-five. It is beyond the scope of this paper to explain the different reactions of an electrical current to the three types of seeds interpolated within a circuit, but it is suggested that the differences may arise from differential mineral content of the seeds as well as other physico-chemical variations.

For moisture content below 14 per cent. for perennial rye-grass, 13.2 per cent. for timothy and 11.8 per cent. for cocksfoot, the moisture meter is not very sensitive, but nevertheless the instrument has proved very efficacious within the range of moisture contents which is considered critical for the seeds of the species dealt with during the process of conditioning them.

Practical Applications.

The Davies Moisture Meter has proved an invaluable instrument in the seed production work of the Welsh Plant Breeding Station, for it has been the means of securing the production of seed of high germinability and vitality as well as of saving a good deal of time in seed conditioning and space in the conditioning houses.

In 1937, one of the team operating the Station's peripatetic thresher tested the moisture content of all the varying seed crops as they came through the thresher, and thus it was possible to determine immediately whether the seed could safely remain in

bags. The conditions during the harvest were so favourable that the Davies Moisture Meter indicated that for the majority of the crops the moisture contents were below the norms for the respective crops, although they had been threshed relatively soon after harvesting. A different state of affairs obtained in 1936, a season when inclement weather made harvesting and threshing more difficult; most of the grass seed crops had to be conditioned on airy floors. The moisture tester proved its worth in such a year by indicating instantaneously the progress of the conditioning so that floor space could be released as soon as the norm was reached.

Even where modern drying plants are being used to condition grass seed, the rapid moisture tester would be the means of providing the seed producer with valuable information when it is realized that grass seeds are more sensitive to the influence of heat and moisture than seeds of grain crops.

As the significance of moisture relations to quality in grass seeds becomes more fully appreciated a moisture meter of the type discussed in this paper should become a standard equipment, not only for members of the wholesale and retail trades, but also for seed growers generally.

The Davies apparuts is completely self-contained, strongly built and very cheaply maintained; the only replacement required, with ordinary care, is a small dry battery once or twice a year. Its construction and operation are so simple that it can be operated satisfactorily by an ordinary farm worker or store man after a few minutes instruction.

The results of the tests have proved so reliable for any given bulk of seed that the moisture content can be determined accurately from a properly taken representative sample within four or five minutes, although this may involve three to five replicated tests of the sample drawn from bulk.

Summary.

1. The role of moisture content as one of the most important factors in determining quality in grass seed is emphasised.

2. Some of the difficulties of the grower in relation to the production of high quality seed, and the need for an apparatus for determining the moisture content of grass seeds rapidly and accurately are discussed briefly.

3. The essential features of the Davies Moisture Meter, an instrument constructed specifically for determining the moisture content of grass seeds, are described.

4. The Davies Moisture Meter has been calibrated for dealing with timothy (*Phleum pratense*), cocksfoot (*Dactylis glomerata*), and perennial rye-grass (*Lolium perenne*) seeds, and curves for these species are given.

5. Each calibration curve is distinctly specific for timothy, cocksfoot and perennial rye-grass, and the results of the investigations indicate that the configuration of the curves for strains within a species are, for practical purposes, identical.

6. Calibration curves for old seeds of timothy and cocksfoot artificially moistened to varying degrees are different in character from curves constructed by using freshly threshed seeds.

7. Some of the practical applications of the Davies Moisture Meter are indicated.

Acknowledgements.

The authors wish to record their grateful thanks to Professor R. G. Stapledon, C.B.E., M.A., for his helpful interest in the work; and to Miss Rhoda Peter Jones, B.A., for reading proofs for the press.

Appendix.

The norm, which means the maximum moisture content at which seeds can be bagged and stored with safety, was found by Williams (2) to be specific. The moisture values established as norms are:

(i) 14.0 per cent. for perennial rye-grass.
(ii) 13.0 per cent. for cocksfoot.
(iii) 13.6 per cent. for timothy.

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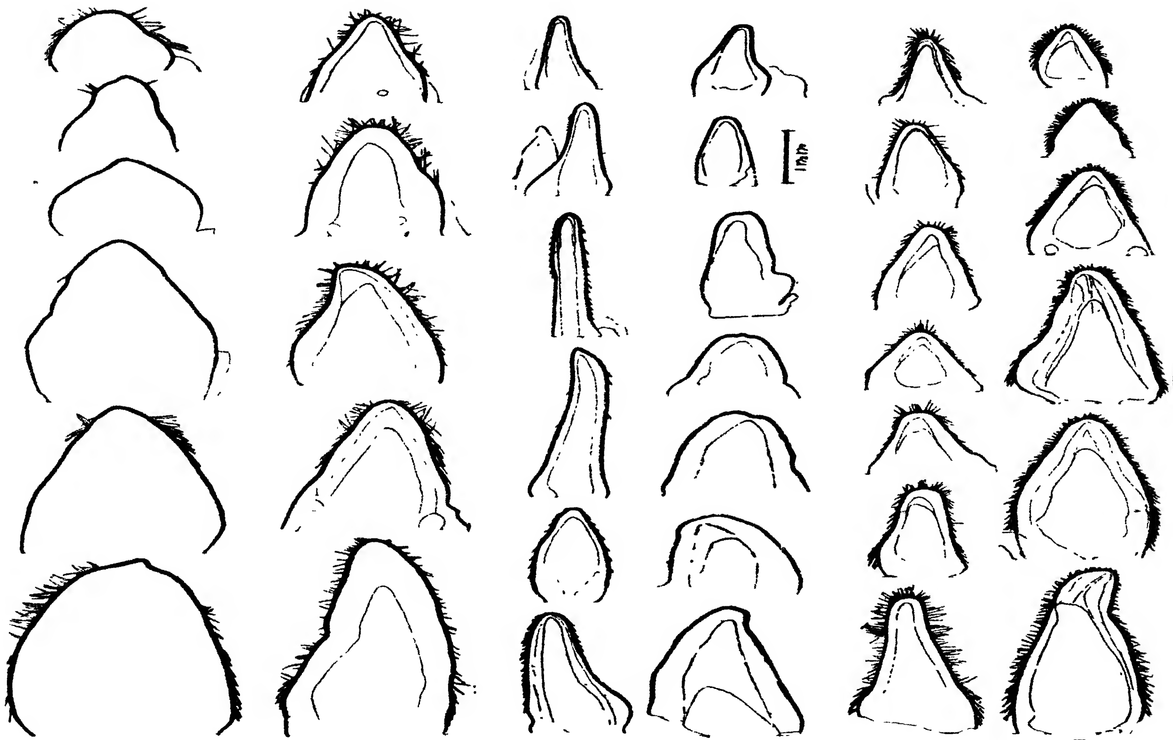
(2) Williams, Myrddin. The moisture content of grass seeds in relation to drying and storing. *Welsh J. of Agric.*, Vol. XIV (1938).



A *Phleum pratense* B *Alopecurus pratensis.* C *tenuis* *Agrostis.* D *canina* E *lanatus* *Holcus* F *mollis*

Text-Fig. Shoot-bud prophylls. The outlines were drawn by means of the Camera Lucida. All at the same magnification.

NOTES ON THE SHOOT-BUD PROPHYLLS OF CERTAIN *PHLEUM*, *ALOPECURUS*, *AGROSTIS* AND *HOLCUS* SPP.

By A. R. Beddows, M.Sc.,
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The shoot-bud prophylls of *Lolium perenne*, *L. italicum* and *Festuca pratensis* show characteristics possessing diagnostic value (see Beddows, 1937). These vegetative characters are especially useful in cases where the rye-grasses and meadow fescue cannot be recognised with certainty in the field by means of the usual criteria.

It therefore seemed desirable to investigate the bud forms in other common grasses in order to see whether they also presented features which might supplement those ordinarily used for diagnosis in the field. The additional species studied were timothy (*Phleum pratense*), meadow foxtail (*Alopecurus pratensis*), brown top (*Agrostis tenuis*), velvet bent (*Agrostis canina*), Yorkshire fog (*Holcus lanatus*), and creeping soft grass (*Holcus mollis*).

The method of examination of the buds was similar to that previously described (Beddows, *loc. cit.*). The results obtained are summarised below, and outlines of typical specimens are shown in the text figure. Although the shoot-bud prophylls may show some variation in form from plant to plant, and even within the same plant, they nevertheless tend to conform to a general type which appears to be characteristic of each species.

Phleum pratense. The buds are plump and are frequently broadest just above the base. The prophyll may be free from hairs, but when present they vary considerably in number as well as in distribution. The hairs, though chiefly found on the bud shoulders, may develop along the sides towards the base, but never apparently up on to the apex (see text fig. Group A).

Alopecurus pratensis. The shoot-buds are plump in meadow foxtail also, but they are relatively more slender with a more rounded apex than those of timothy. The prophylls, however, are generally hairy, and the hairs are fairly uniformly distributed not only along both edges, but also as a rule on the apex as well (see text-fig. Group B).

In the case of very plump buds the prophyll may appear to be devoid of hairs, but if examined from the sides, the hairs will usually be seen.

AGROSTIS TENUIS. The shoot-buds found in this species are relatively long and more or less finger-like in shape. The hairs, which are developed on one or both sides, but never on the apex, are short and vary considerably in number. Certain buds, especially those found at the nodes of aerial stems, may be of great length; one such specimen measured 11 mm. The shape of these buds and the distribution of the hairs on them is similar to those of basal shoot-buds (see text-fig. Group C).

AGROSTIS CANINA. The shoot-buds of velvet bent, in contrast to those of *A. tenuis*, are relatively short and broad with the tip or side of the apex somewhat flattened. The prophylls always appeared to be quite glabrous (see text-fig. Group D), but one bud examined proved exceptional in that when magnified about 55 diameters it showed a small single hair. This hair was not visible with a x 10 field lens.

HOLCUS LANATUS and H. MOLLIS. The shoot-buds in Yorkshire fog seem to be generally more slender than those of creeping soft grass, but they are otherwise more or less similar in shape. The buds in both species are covered with hairs on the face of the prophylls as well as along their sides. The hairs on the prophyll edges in *H. lanatus* are rather longer, more ragged in appearance and less densely arranged than those in *H. mollis* (see text-fig. Groups E and F).

The value of these characteristics for classification was recently demonstrated in the case of some young diseased plants received at the Station as *H. mollis*. The condition of the plants was such that the ordinary vegetative characters usually depended upon for diagnosis proved inadequate for the purpose. A shoot-bud found on one of the plants, examined under the binocular microscope, suggested by the length and arrangement of the hairs that the plant was really *H. lanatus*. This view was later confirmed by the sender of the material.

REFERENCE.

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THE ROUTINE BACTERIOLOGICAL EXAMINATION OF ACCREDITED MILK.

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Introduction.

The development of the higher grades of raw milk has been a feature of dairy farming in Wales during the past ten years. The number of Tuberculin Tested herds and the volume of milk of this designation sold has been proportionately higher than in England since about 1927.

The production of Accredited Milk (previously termed Grade A milk) was not taken up with such enthusiasm, however, until 1935, when the Milk Marketing Board bonus became available for this grade. Only 41 farms were licensed to produce Grade A milk on 1st April, 1935, but there has been a steady increase during the past two years, so that at present over 2,000 are licensed to produce Accredited Milk. As many as 15 to 20 per cent. of the dairy farms in the recognised dairying areas are licensed to produce this grade, but the average for the Principality is only slightly over 10 per cent.

TABLE I.

Accredited Milk Producers. Wales. 1935-7.

County.	*Registered Milk Producers 1st January 1937.*	*Grade A Producers 1st April 1935.*	*Number of Accredited Producers.* 1st June 1935.	1st June 1936.	1st June, 1937. Number	1st June, 1937. per cent.
Anglesey	629	3	1	15	16	2.5
Caernarvon	1,286	6	11	29	46	3.6
Denbigh	1,491	1	69	205	248	16.5
Flint	1,500	13	155	285	324	21.6
Merioneth	627	0	2	6	7	1.1
Montgomery	1,087	0	115	178	182	16.7
Brecon	539	0	17	42	48	8.9
Radnor	202	0	4	18	23	11.3
Cardigan	1,526	1	7	146	224	14.7
Carmarthen	3,932	1	74	331	512	13.0
Pembroke	2,082	6	14	42	96	4.7
Glamorgan	2,649	8	28	101	135	5.1
Monmouth	1,205	2	14	59	90	7.5
Total	18,758	41	511	1,457	1,951	10.4

One to three milk samples are examined for each producer immediately before accreditation, and subsequently the usual practice is to aim at quarterly routine samples, although the actual number taken varies from one to ten per annum.

Prelicence samples are taken by members of the agricultural or public health staff of the counties, while the post licence sampling is carried out by various officials according to local organisation, including members of the agricultural staff, veterinary officers, sanitary inspectors, and weights and measures inspectors.

In some counties sterile plungers and dippers are used, but in others no special sampling apparatus is provided, with the exception of the sample bottle. These bottles are of six ounce capacity and are sterilised in the laboratories. The actual method of sampling, whether from bottled milk, churns or directly from the cooler varies from county to county. Walters (1932), Keith (1932) and Stine (1937) have shown that it is difficult to obtain a homogenous sample for bacteriological purposes from a churn or full bottle which have been standing some time. The Ministry of Health Memorandum (1937) states that if the milk is in sealed bottles or cartons the sample should consist of one such bottle or carton. During the past two years, however, many sampling officers, in an attempt to save transport costs, have been taking six ounce samples of Tuberculin Tested and Accredited Milk from sealed bottles and cartons. Instructions for ensuring representative sampling from churns are also given in the above Memorandum. It is suggested that further investigational work should be carried out in order to demonstrate to sampling officers the need for a strict technique of sampling. Samples from some counties were forwarded to the laboratories in insulated ice boxes during the summer months.

On arrival, the samples were kept at atmospheric (shade) temperatures until 6 p.m. on the day of production if from morning milk, and until 10 a.m. on the next day if from afternoon milk. The morning milk samples were further kept overnight at 40° F., and examined at 10 a.m. on the following day.

During 1936 all samples were graded by means of the plate count on milk agar at 37° C. and the presumptive coliform test as described in the Ministry of Agriculture Bulletin No. 46 (1934). During 1937 grading was done by means of the modified Methylene Blue test and coliform test as prescribed by the Ministry of Health Memorandum (1937). It should be noted, however, that three McConkey broth tubes each inoculated with

1/100 ml. milk were used during the two years for the coliform test. For purposes of comparison, the three tests—plate count, coliform test and methylene blue reduction—were carried out concurrently on a number of samples.

The standards prescribed for Accredited milk during 1936 were colony count not over 200,000 per ml. and no coliform organisms in 1/100 ml., and for 1937, no decolourisation of methylene blue within $4\frac{1}{2}$ hours during May to October; or within $5\frac{1}{2}$ hours during November to April; and no coliform organisms in 1/100 ml.

Results of Routine Examinations.

Over 2,000 prelicence samples and over 7,000 post licence samples were examined during the period under review. As expected, more of the samples taken before accreditation failed to attain the desired bacteriological standards than of the post licence samples (Table II). Five authorities have insisted on the provision of steam sterilisation of utensils for herds of all sizes before granting an Accredited licence, whereas in five other counties the use of steam is not obligatory, though its use for the larger herds, particularly where milking machines are used, is recommended. In the case of the smaller farms, with less than twelve cows or so in milk, the work is generally carried out by family labour, and the use of boiling water for sterilisation in such circumstances has often proved most satisfactory. It is obvious, however, from the results obtained that both prelicence and post licence samples are much poorer in hygienic quality in the counties where steam sterilisation is voluntary as compared with the districts where it is compulsory.

Only 7 per cent. of the total number of post licence samples from the compulsory sterilisation group failed to attain accredited standards, as compared with 15 per cent. in the case of the counties where efficient sterilisation was not enforced. The percentage failures to attain accredited standards for different counties ranged from 4 to 26.

The relative number of samples failing was significantly greater during 1937, only 17 per cent. of the 1936 samples failing as compared with 25 per cent. during 1937. Not only do the annual average results show this, but it is observed during nine different months. (Table III.) This deterioration in quality is particularly noticeable during the "summer" period—May to October—when a more lenient Methylene Blue reduction standard

was in force during 1937, though no seasonal adjustment was used for grading during 1936. It will be shown later that the poorer results during 1937 cannot be accounted for by stricter methods of grading; actually the Methylene Blue reduction and coliform test combination of 1937 is comparable in this respect to the plate count and coliform test as used during 1936. Climatic conditions were very similar during the two years and cannot be assumed to be the responsible factor. About a fifth

TABLE II.
Accredited Milk Samples.
For two year period—1st May, 1935, to 30th April, 1937.

County.	*Accredited Licences 1st March, 1937.*	*Prelicence samples.* *Number examined*	*Failing to attain Standards.* *No.*	*%*	*Official post licence samples.* *Number examined*	*Failing to attain Standards.* *No.*	*%*
		Steam sterilisation of utensils compulsory.					
A	17	25	1	1.0	165	25	15.1
B	10	17	0	0.0	165	11	8.5
C	237	—	—	-	683	14	6.4
D	8	8	0	0.0	18	4	8.3
E	86	181	35	19.3	225	10	4.4
Total ...	388	231	36	15.5	1,286	97	7.5
		Steam sterilisation of utensils voluntary.					
F	315	445	57	12.8	2,808	285	10.1
G	180	351	104	29.6	693	82	11.8
H	52	118	35	29.6	318	50	15.7
I	216	257	7	30.0	658	132	20.0
J	188	832	143	17.2	1,056	274	25.9
Total ...	1,251	2,003	416	20.8	5,533	823	14.9

of the total number of samples were forwarded during 1937 in boxes not iced during the summer months, whereas all the samples forwarded during the warm weather of 1936 were iced during transit (Table V). This may have some influence on the results, but it is significant that a comparison of the iced samples also shows the same marked deterioration.

The 1937 results include samples from over 600 newly-accredited producers who were licensed during the end of 1936 and early in 1937. It is suggested that the poorer quality of the milk from these farms may afford an explanation of the deteriora-

tion in general quality. It is well known that most of the producers that had gained experience during the Clean Milk Competitions of 1924-34, became accredited during 1935-36, and that licences were granted during 1937 to many producers who had very little practice in the production of milk of low bacterial content. They were able to submit a few prelicence samples during the winter months which satisfied the prescribed conditions, but were unable to maintain the accredited standards during the warmer six months. In order to prevent a recurrence of these conditions Advisory Milk Schemes have again been organised in several counties.

TABLE III.

Accredited Milk.

Total official "post licence" samples from Anglesey, Caernarvon, Cardigan, Carmarthen, Merioneth, Montgomery and Flintshire.

Month.	*1936.* Total samples examined.	No. failing.	% failing.	*1937.* Total samples examined.	No. failing.	% failing.
January ...	203	7	3.4	331	43	12.9
February ..	195	10	5.1	403	27	6.6
March ...	225	18	8.0	318	21	6.6
April ...	214	9	4.2	307	52	16.9
May ...	204	18	8.8	419	122	29.1
June ...	240	52	21.6	369	116	31.4
July .	201	23	11.4	372	161	43.2
August ..	192	77	40.1	233	167	71.6
September ..	396	128	32.3	353	142	40.2
October ...	318	72	22.6	227	65	28.6
November ...	386	75	19.4	629	120	19.0
December ..	266	40	15.0	383	32	8.3
Total ..	3,040	529	17.4	4,344	1,068	24.6

An examination of the monthly results show that very few samples failed to reach accredited standards during winter, but the number of failures was excessively high during July to September, as many as 72 per cent. failing during last August. The percentage failures during this period were much higher in the case of samples from counties where steam sterilisation was not compulsory.

Advisory work on a number of accredited farms has shown that the large number of poor samples during the warm weather is undoubtedly due to a lack of adequate cooling facilities combined with inefficient sterilisation of utensils. During sixty

visits to farms in the Mid and South Wales area carried out during June to September of 1936 and 1937, the mean temperature of the milk directly after passing over the cooler was found to be 66° F., with a maximum of 80° F. and a minimum of 55° F. Thus in no single case was the milk cooled below 50° F. Electrical coolers and refrigerators have been installed on a number of these farms recently, so that it will be possible to

TABLE IV.

Comparison of winter and summer results.

Season.	*1936.*		*1937.*		*1936-7.*	
	No. of samples examined.	*% failing.*	*No. of samples examined.*	*% failing.*	*No. of samples examined.*	*% failing.*
January, February and December	664	8.6	1,117	9.1	1,781	8.9
July, August and September	789	28.8	958	49.0	1,747	40.0

TABLE V.

Influence of conditions of transport of samples on bacterial content.

Year.	*Transit.*	*Examined by*	*June to August.*	
			No. of samples examined.	*Per cent. failing to attain standards.*
1936	Insulated iced boxes	Plate count and coliform test	487	23.4
1937	Insulated boxes without ice.	Methylene Blue reduction and coliform test	439	40.0

cool the milk below 50 F. during the warmest weather. The systematic bacteriological examination of milk bottles taken from steam chests after sterilisation has been carried out on a number of these farms. The results of the examination of 24 bottles per annum, for each farm, has shown that inefficient sterilisation is common, even when steam is used. At present a similar survey

is being carried out on milk bottles from farms using boiling water for sterilising dairy utensils.

A comparison of Grading by different tests.

The Ministry of Health regulations regarding bacteriological tests for graded milk (Memorandum 1937) state that "it is not necessary that every sample of accredited milk should be submitted to both methylene blue and coliform tests, and Licensing Authorities which require to have frequent tests made of samples of producers' milk may find it convenient to have most of the samples examined by the methylene blue test alone, reserving the coliform test for occasional use." It is known that many laboratories in the country do not use the coliform test. As Faulds (1937) points out, the reductase test can be carried out by semi-skilled labour, but when the coliform test is included; which he considers necessary for accuracy, the dilutions entail time, material and skill, and the end-result is a test requiring the same skill, time and material as the old plate count and coliform test.

Since both tests have been used for all samples reported in this paper, it is thought that a comparison of grading accredited milk by both tests and by the methylene blue test only, would be of some interest. A preliminary comparison of this nature was reported by Thomas and Tudor (1937). They examined 400 winter and 400 summer samples and found that the ratios of samples failing to attain the prescribed bacteriological standards by both tests (methylene blue and coliform) as compared with methylene blue test only, were 100 : 73 in winter and 100 : 88 during summer. A similar comparison of a much larger number of samples is given in Tables VI, VII and VIII. When the methylene blue test was used alone as a means of grading, 59 to 71 per cent. of the failures obtained by the use of both tests were obtained. It is significant that the ratios of failures for the methylene blue test, as compared with those for both tests, are lower for the winter than the summer The majority of the samples examined were from morning milk, which were transported and kept at atmospheric temperatures of 45° to 55° F. during winter, and subsequently stored overnight (16 hours) at 40° F.

Malcolm and Leitch (1936), Mattick (1937) and Thomas and Tudor (1937) have shown that the storage of milk samples at such low temperatures during the colder periods results in a

marked retardation of the reducing activity of the milk flora. Powell (1938) has compared the methylene blue reduction times of duplicate samples of morning milk stored overnight at 40° and 60° F. respectively. The mean reduction times of 120 samples examined by her at Aberystwyth, during the cold weather of November and December, were 8.45 hours after storage at 40° F. and 5.10 hours after storage at 60° F. Only 11 per cent. of the former were reduced within 5½ hours, but 52 per cent. of the latter were reduced in this time. It is thus evident that the refrigeration of samples before testing, results in unduly long reduction times during winter, and the methylene blue test is not a reliable index of the commercial keeping quality of the milk under these conditions. It is suggested that samples of morning milk should be stored overnight at 50° to 55° instead of at 40° F. during cold weather.

The data presented in the following tables also show the importance of using the coliform test in conjunction with the

TABLE VI.

Comparison of grading by Methylene Blue and Coliform tests. Post licence samples, 1937

Season.	*"Winter" period. Nov.—April.*		*"Summer" period May—Oct.*		*1937.*	
Total number of samples examined	2,096		1,932		4,028	
	No. of Samples	*Ratio.*	*No. of Samples*	*Ratio.*	*No. of Samples*	*Ratio.*
Samples failing to attain Standards on Methylene Blue test and/or Coliform test ...	244	100	763	100	1,007	100
Samples failing on both tests ...	49	20	407	53	456	45
Samples failing on Methylene/Blue test only ...	110	45	151	20	261	26
Samples failing on Coliform test only	85	35	205	27	290	29
Total samples failing Methylene Blue Standards ...	159	65	558	73	717	71
Total samples failing Coliform test Standards ...	134	55	612	80	746	74

methylene blue test, particularly during the winter months. If the methylene blue test is used alone, as many as 40 per cent. of relatively poor samples (*i.e.* showing the presence of coliform organisms in 1/100 ml.) attain accredited standards during the colder weather. There is ample evidence that coliform organisms grow rapidly in milk held at 60° F. to 70° F., but development

TABLE VII.

The significance of the Coliform test in grading Accredited Milk. (Including data for 1936 and 1937).

Season.	*Samples failing to attain Accredited Standards on* — *Methylene Blue test and/or Coliform test.*	*Samples failing to attain Accredited Standards on* — *Methylene Blue test alone.*	*Ratio.*
" Winter " (Nov.—April)	372	221	100 : 59
" Summer " (May—October)	1,078	711	100 : 66
Total	1,450	932	100 : 64

TABLE VIII.

Comparison of grading by Plate Count, Colifrm test, and Methylene Blue

	" Winter " period Nov.—April.		*" Summer " period May—October.*		*Total year.*	
Total number of samples examined	1,304		1,508		2,812	
	No. of Samples	*Ratio.*	*No. of Samples*	*Ratio.*	*No. of Samples*	*Ratio.*
Samples failing on Methylene Blue test and/or Coliform test ...	211	100	543	100	754	100
Samples failing on Colony count and/or Coliform test ...	195	92	491	90	686	91
Samples failing on Colony count ...	130	61	276	50	406	51
Samples failing on Coliform test ...	110	52	351	64	461	61
Samples failing on Methylene Blue test ...	140	66	380	70	520	68

at 50° F. to 55° F. is comparatively slow, and little or no growth takes place within 24 hours or so at temperatures below 50° F. The presumptive coliform test is thus a better index during winter than in summer of hygienic milk production.

A comparison of grading by means of the methylene blue test combined with the coliform test on the one hand and a combination of the plate count and coliform test on the other, shows that the latter is rather more lenient (Table VIII). If any of these three tests are used alone, however, the number of samples failing to attain the respective Grade A or accredited standards is much less.

Methylene Blue Reduction Times.

A study of the frequency distribution of the reduction times during different months (Tables IX and X) show that only 9.6 per cent. of the samples were reduced within 5½ hours during the winter period, whereas 28.5 per cent. were reduced in 4½ hours during the summer period.

TABLE IX.

Frequency distribution of Methylene Blue Reduction Times.

Month.	*Methylene Blue Reduction 37 ° C. (Hours).*													*Total Samples.*
	½	1	1½	2	2½	3	3½	4	4½	4½+	5	5½	5½+	
Nov. ...	2	4	8	3	7	8	8	12	20	—	12	17	692	782
Dec. ...	—	—	—	—	1	4	2	—	2	—	3	6	408	426
Jan. ...	2	1	—	2	5	3	2	4	14	—	8	9	419	469
Feb. ...	—	—	2	3	2	1	8	5	5	—	5	12	518	551
March ...	8	3	2	2	8	4	5	6	11	—	4	11	468	522
April ...	—	—	5	3	1	2	7	8	5	—	7	10	811	858
Total ...	7	8	12	18	19	17	27	35	57	—	89	65	2,811	8,108
May ...	4	3	10	6	16	2	11	18	36	352				452
June ...	5	16	7	11	18	17	5	12	20	345				449
July ...	14	18	14	15	5	11	12	21	28	280				412
Aug. ...	40	80	14	21	16	10	9	18	80	155				888
Sept. ...	38	26	19	21	5	17	18	16	28	480				668
Oct. ...	15	3	7	9	9	6	9	6	19	841				420
Total ...	111	96	71	88	64	68	64	81	156	1,958				2,784

Several Medical Officers and Agricultural Organisers have suggested that if the results of the methylene blue test would be reported in three or four classes on the lines suggested by Barthel and Orla Jensen (1912) for the old method, it would be helpful for advisory work amongst dairy farmers. Though Wilson (1935) states that for public health purposes probably

only two classes need be made on the basic of cleanliness, namely (*a*) milk that is suitable, and (*b*) milk that is unsuitable for human consumption, he admits the possibility of dividing milk into three or four classes.

TABLE X.

Methylene Blue Reduction.

Reduction Time (hours).	*Winter" (November—April).*		*" Summer " (May—October).*	
	No. of samples.	*per cent.*	*No. of samples.*	*per cent.*
½	7	0.2	111	4.0
1	8	0.3	96	3.5
1½	12	0.4	71	2.5
2	13	0.4	83	3.0
2½	19	0.6	64	2.3
3	17	0.6	63	2.3
3½	27	0.9	64	2.3
4	35	1.1	81	2.9
4½	57	1.8	156	5.7
4½+	—	—	1,953	71.5
5	39	1.2	—	—
5½	65	2.1	—	—
5½+	2,811	90.4	—	—
Total	3,108	100.0	2,784	100.0

An attempt has therefore been made to formulate a third class to include samples with very low reduction times, and poor keeping qualities (Table XI).

TABLE XI.

Methylene Blue Reduction.

A suggested method of grading for advisory purposes.

Class.	*" Summer " period.*			*" Winter " period.*		
	Reduction times.	*Per cent. "Summer" samples.*	*Per cent. August samples.*	*Reduction times.*	*Per cent. "Winter" samples.*	*Per cent. March samples.*
1	Not reduced in 4½ hours	71.5	45.8	Not reduced in 5½ hours	90.4	89.6
2	Reduced in 4½ hours ...	24.5	42.4	Reduced in 5½ hours ...	7.1	7.1
3	Reduced in ½ hour ...	4.0	11.8	Reduced in 3 hours ...	2.5	3.3
Samples		2,784	388		3,108	522

Summer samples reduced in half an hour and winter samples reduced in three hours are included in this class. When applied to the data presented in this paper it will be seen that 4 per cent. of the summer samples and practically 12 per cent. during the warmest month (August) are reduced in half an hour. A comparable class for winter samples, to include approximately 10 per cent. of the samples, would have to be fixed at 5½ hours. If in this case the third class includes all samples reducing within three hours; 2.5 per cent. of the total samples and 3.30 per cent. of the March samples (the winter month showing the largest number of samples in this class) are reduced in this time.

If a class to include very good quality milk (approximately comparable to the "Certified" milk of the Milk Special Designations Order, 1923) is required, then it is suggested that this may be fxed at seven hours for the summer period and nine hours for the winter period. Frayer (1937) states that it is proposed to change the minimum reduction time from 5½ to 8 hours for Class I milk in the 7th Edition of the American Public Health Association's Standard Methods of Milk Analysis. Thomas and Tudor (1937) found that 10.5 per cent. of 400 summer samples were not reduced by the modified test in seven hours, whilst Phillips and Simons (1938) found that 50 per cent. of 161 accredited milk samples examined at Aberystwyth during November to January were not reduced in nine hours, and 14 per cent. not reduced within ten hours. Wilson (1935) examined Certified milk from thirteen different farms, and obtained an average reduction time of 10.12 hours for 60 samples taken during January and February, and 9.15 hours for 60 samples taken during May and June.

The writers consider, however, that the plate count on milk agar is more suitable for the advisory grading of milk of this class. The experimental error of the plate count is not serious with low count milk, whereas the reproducibility of the methylene blue test becomes less accurate with the longer reduction times. Furthermore, the plate count is more convenient (as well as more economical of labour) for routine laboratory work in this case.

Comparison of Grade A Milk and Accredited Milk.

A comparison of the bacteriological quality of Accredited milk examined during the last two years with that of (what was then termed) Grade A milk examined during the ten year period 1925-35, shows that there has been no general deterioration

(Table XII). Eleven per cent. of the Grade A samples failed to satisfy the prescribed standards as compared with 13 per cent. of the Accredited milk samples.

TABLE XII.

A comparison of the bacteriological quality of Grade A milk and Accredited Milk produced in Wales.

Period.	*Grade.*	*No. of samples examined.*	*Samples attaining designated standards.*	
			No.	*Per cent.*
1925-35 ...	Grade A (T.T.) and Grade A	5,133	4,555	89
1936-37 ...	Accredited	6,902	5,982	87

Summary.

(1) The development of Accredited milk production in Wales is discussed. As many as 15 to 20 per cent. of the dairy farms in the recognised dairy areas are now licensed to produce this grade of milk.

(2) The results of the bacteriological grading of approximately 9,000 samples of accredited milk are given, and the influence of some hygienic factors of production shown. The results are much poorer for counties where steam sterilisation of utensils is voluntary as compared with the data for counties where it is compulsory for accreditation.

(3) Grading by means of the methylene blue test alone is much more lenient, particularly during winter months, than grading by a combination of methylene blue and coliform tests. If methylene blue reduction is used as the only index of hygienic quality, as many as 40 per cent. of relatively poor samples may attain accredited standards during cold weather.

(4) It is suggested that this may be due to the marked retardation of methylene blue reduction as the result of refrigerating morning samples for 16 hours or so, after being transported and held for twelve hours at low atmospheric temperatures. The storage of morning milk samples during winter months at 50°-55° F., appears to be better than refrigeration, if a true index of the keeping quality of the milk is desired.

(5) The use of the modified methylene blue tests combined with the coliform test and grading according to the standards prescribed in the Ministry of Health Memorandum (1937) serves to retain a bacteriological standard for accredited milk compar-

able to that prescribed for Grade A milk when the plate count and coliform test were used. It has been found that the new method is actually somewhat stricter, even when the comparison is made with colony counts obtained on milk agar. The use of a single test, however, whether colony count, coliform test or methylene blue reduction results in a much more lenient grading.

(6) The frequency distribution of methylene blue reduction times during the twelve months of the year has been studied and a suggested method of grading for advisory purposes outlined.

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THE BACTERIOLOGICAL GRADING OF ICE CREAM.

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Introduction.

The steadily increasing manufacture of ice cream in this country provides a profitable means of using a proportion of the surplus liquid milk produced during spring and summer. Much of the ice cream now prepared in our larger towns is manufactured under scientifically controlled hygienic conditions, while the use of insulated containers supplemented by solid carbon dioxide as a freezing agent, has enabled large quantities of this better quality produce to be transported to our smaller towns.

It appears that ice cream has been made in England since the eighteenth century, but it is only during the last twenty years that it has been developed commercially, whilst it is only very recently that its value as a food product has been seriously considered. Reliable information as to the amount produced annually in England and Wales does not seem to be available. Eckles, Combs and Macy (1936) state that the average consumption per capita in the United States during 1910 was about one gallon and that this had increased to three gallons by 1929, followed by a drop to approximately two gallons during 1930-3. The total proportion of the milk supply used for ice cream was 2.6 per cent., or practically the same proportion as used for calf-feeding—the produce roughly of 750,000 cows.

Investigational work carried out during the last forty years has shown the need for bacteriological control of the manufacture and distribution of ice cream.

In the present article a brief review of the previous work is given and the results of the examination of the ice cream supply of a small town (approximately 10,000 inhabitants) are discussed.

Bacteriological content.

The first systematic study of ice cream in this country was conducted by MacFadyen and Colwell (1895). The maximum

numbers of organisms found by these observers was just over 1,000,000 per ml. in shop samples and 7,000,000 in barrow samples. Nield-Cook (1896) obtained counts as high as 14,000,000 per ml., and isolated *Bacterium coli, Proteus vulgaris, Pseudomonas fluorescens* and many types of cocci from several samples. Klein (1902) gives the results of the bacteriological examination of samples of ice cream collected in London. He isolated many organisms of the coliform group during the investigation. The majority of the organisms found were non-sporing and Klein was of the opinion that contamination occurred after heating the mix, that is during the cooling and freezing processes. Buchan (1910) inspected the premises of 50 manufacturers of ice cream in Birmingham; investigated the methods of manufacture and carried out bacteriological examinations. The average colony counts he obtained were as follows :—

	Standard Agar. 2 *days at* 37° *C.*	*Gelatine.* 3 *days at* 22° *C.*
Immediately after heating the mix	379,000	867,000
After cooling	6,862,000	13,043,000
After freezing	34,467,000	372,213,000

Of 50 samples examined after freezing, 47 showed the presence of coliform organisms, no less than 11 producing acid and gas in bile-salt-glucose-broth in 1/10,000 ml. dilution. These results show heavy contamination during manufacture, attributed by Buchan to insufficient initial heating, and contamination during cooling and freezing from unsterile vessels, addition of unclean ice to hasten freezing, and to general unhygienic treatment. Ayers and Johnson (1915) examined 71 summer and 28 winter samples of retail ice cream in Washington. The summer samples had an average colony count of over 37,000,000 and the winter samples over 10,000,000. Lactic acid producing organisms were the dominant bacteria during both seasons; peptonising organisms being relatively more abundant in winter. Coliform organisms were found to be present in 1/10 ml. in 88 per cent. of the samples. Fay (1923) conducted an ice cream competition in Kansas. The bacterial counts of 115 samples ranged from 1,500 to 47,000,000. Three-fourths of the samples contained less than 300,000 organisms per ml, and half of them less than 100,000 per ml. Rawlinson (1926) examined 35 samples taken from various sources in London during July and August. The majority contained over 100,000,000 organisms per ml., and *Clostridium welchii* was detected in 1/100,000 ml. in 17 samples.

The above results obtained by the early investigators show

that the bacterial content of ice cream up to recent years was very variable. Comprehensive reviews of the literature are given by Hammer (1928), Tanner (1932), Sommer (1935) and Harvey and Hill (1937).

There is a considerable amount of evidence to show that the freezing and low temperatures at which ice cream is held do not result in the complete destruction of pathogens that may be present. Davis (1914) in studying the longevity of haemolytic streptococci in milk products, found that the number of streptococci which he added to ice cream, decreased only very slightly over a period of eighteen days, without any diminution in virulence. Prucha and Brannon (1926) showed that *Bacterium typhosum* could remain viable in ice cream for a long time. They prepared sterile ice cream mix with 50,000,000 cells of *B. typhosum* per ml., froze and stored it at 25°F. In a week the number of organisms dropped to 9,000,000, in forty days to 900,000, in six months to 60,000, and in eleven months to 51,000 per ml. They could still demonstrate the presence of living typhoid organisms in two years. Wallace and Crouch (1933) found that *Salmonella enteritidis*, *S. aertrycke*, *Brucella abortus*, *B. melitensis* as well as human, bovine and avian strains of *Mycobacterium tuberculosis* survived freezing in ice cream at 10°F. for thirty months.

Among dairy products, ice cream undoubtedly ranks next to milk as a cause of epidemics. Savage (1913) lists six ice cream borne food poisoning outbreaks of the Salmonella type, with 353 cases and one death, in English towns during the period 1900-10. Ice cream epidemics have been summarised by Fabian (1926*a*). His report covers 35 outbreaks, some of which were extensive, involving over 1,800 cases, while others were very small. Twenty-one of these epidemics were due to *Bacterium typhosum*, the other diseases transmitted being scarlet fever, diphtheria and intestinal disturbances. This subject has also been reviewed by Tanner (1933) and Harvey and Hill (1937). The recent improvements made in methods of manufacture, particularly the use of efficient pasteurisation of the mix, have limited the spread of disease through ice cream.

Sources of bacteria in ice cream.

The bacterial flora of ice cream is derived from two main sources, namely, the ingredients used (particularly the milk products) and from utensils and equipment during manufacture. Unless the cream used is pasteurised it is generally the most important source. Even pasteurised cream which has been transported for a distance at atmospheric temperature, and held

for some time before using, will contribute a large number of organisms. Thus Fabian and Cromley (1923) during a study of ice cream made under factory conditions found that the cream was used from one to four days after pasteurisation, and that the bacterial content of 98 samples varied from 10,000 to 8,000,000 with an average of 1,100,000 per ml. They also found that the condensed milk used had an average count of 600,000 bacteria. Bulk condensed milk should be kept in cold store or extensive bacterial development may take place. Milk powder should not contribute many organisms, but butter will contain large numbers of lactic acid producing streptococci. The bacterial flora of the gelatine will indicate the care taken in its manufacture. The above investigators found the gelatine used in the factory to have an average count of 2,500,000. Brannon and Tracy (1925) suggest that many gelatine manufacturers are producing a product of low bacterial content. Thus 50 per cent. of the 142 samples examined by them contained less than 20,000 organisms per gram. Fay and Olson (1927) examined 50 gelatine samples, 31 from eight different manufacturers and 19 collected from ice cream plants. The bacterial content varied from 10 to 108,000,000 per gram, which is equivalent to a contribution of from 0.05 to 540,000 per gram of raw mix, when 0.5 per cent. gelatine is used. In addition to the small amount used in a mix, the heat to which gelatine is subjected in dissolving limit its influence on the bacterial content of ice cream. Normally the other ingredients used, such as sugar, flavouring materials and colours, are of little significance as a source of bacteria, though the writers have found badly contaminated sugar with counts ranging from 760,000 to 7,200,000 per gram.

Influence of manufacturing operations.

Pasteurisation of the ice cream mix at temperatures of 145° to 155°F. for thirty minutes results in a high percentage destruction of the bacterial content, and destroys all pathogenic bacteria that may be present. Hammer and Sanders (1919) using pasteurising exposures from 142° to 150°F. for twenty minutes, found that in nine trials the counts after pasteurisation ranged from 170 to 66,000 per ml. They suggested that the high concentration of sugar in the mix may have an influence on the pasteurisation efficiency obtained. Fabian and Cromley (1923) during forty-six trials under commercial conditions—the mix being pasteurised for thirty minutes at 150°F.—obtained a destruction of from 94.5 to 99.9 per cent. of the bacteria, with an average of 98.97 per cent. In comparisons made by Fay and Olson (1924), pasteurisation of the mix at 150°F. for thirty

minutes resulted in an average destruction of 98.09 per cent. of the bacteria. A study of pasteurisation of ice cream mix at various temperature—time combinations was made by Dubois and Martin (1938). The percentage destruction was very high in mixes made from raw dairy products, ranging from 98.46 to 99.91, and there was no significant difference in the results obtained with the various combinations used. In the case of mixes made from previously pasteurised dairy products however, the pasteurisation efficiencies obtained were much lower (82.78 to 89.91), whilst the use of more severe heat treatments increased the efficiency. There is a developing tendency to pasturise ice cream mix in excess of 145°F. for thirty minutes. The effect on the physical condition of the milk fat is overcome by homogenisation and any heat flavour is masked by the flavouring materials. The use of higher temperatures is stated by some American investigators to be helpful in eliminating coliform organisms. While Ayers and Johnson (1913, 1915a), Beavens (1930a, 1930b), Henneberg and Wendt (1935) and Wilson (1935) have shown that some members of the coliform group can survive pasteurisation in milk at 145°F. for thirty minutes, resistant strains are not common and Vernon and Walker (1936) state that of 1,000 cultures of coliform bacteria isolated by them from milk samples taken from various parts of a pasteurising plant only thirty-five proved resistant to laboratory pasteurisation. Fabian and Coulter (1930) working with cultures of *Bacterium coli* and *Bacterium aerogenes* found that the percentage destruction of these organisms in ice cream mix heated at 150°F. for thirty minutes was considerably greater than at 145°F., though some cells of a few cultures survived. All cultures were totally destroyed at 155°F. They also suggest that ice cream has a greater protective effect than skim milk for members of the coliform group. Beavens (1930a) showed that the survival of *Bacterium coli* at pasteurising temperatures bears a relation to the concentration of lactose up to 20 per cent. in the medium heated. He suggested that sucrose may have the same protective action. Anzulovic (1932) has confirmed this. He found that whereas thirteen cultures of *Bacterium coli* survived heating in ice cream at 145°F., only two did so in milk. Sugar, gelatine, serum solids and fat showed some protective action. The protective action of casein has also been commented upon by Zavagli (1933). Martin (1936) advocates the pasteurisation of all the ingredients, except the flavour, at 150°F. for thirty minutes.

In cases where cream is twice pasteurised before adding to

the mix, the selective action of pasteurisation may be pronounced, and the development of thermoduric as well as thermophilic organisms is to be expected. This problem does not seem to have been investigated with relation to ice cream manufacture.

The hygienic production of ice cream thus involves efficient pasteurisation of the mix and care in the elimination of subsequent contamination. It is possible to distribute safe liquid milk without pasteurisation as long as adequate public health measures are taken from cow to consumer. Since ice cream must be heated to dissolve some of the ingredients and to enable efficient homogenisation, it is logical to use holder pasteurisation as a means of bacteriological control.

Some recontamination from equipment is difficult to avoid in the case of ice cream, since it comes into contact with complicated machinery, difficult to sterilise, such as homogenisers and freezers. Fabian and Cromley (1923), Fay and Olson (1924), Fabian (1925) and Olson and Fay (1925) showed that homogenising the mix usually results in an increase in the colony count, due to contamination from the machine and possibly the breaking up of bacterial clumps.

After homogenisation the mix is generally cooled at once to a temperature of 32°-40°F., and then aged for 24-48 hours at this temperature. Ageing improves the body and texture of the finished product. Hammer (1912), Peterson and Tracy (1922), Fabian and Cromley (1923) and Fay and Olson (1924) found that ageing for a reasonable time at this temperature did not result in a significant increase in bacteria, but if the process was prolonged a marked development took place.

The freezing of an ice cream mix often results in a considerable increase in bacterial content as determined by the plate count. A small apparent increase may be expected, due to the breaking up of bacterial clumps during the agitation of the ice cream, but very marked increases have often been observed which can only be attributed to contamination from the freezer. A comprehensive review of investigations on this subject is given by Sommer (1935).

Dahlberg and Marquardt (1933) found that steam sterilisation of freezers was most effective, whereas chlorine solution did not penetrate the bearings, and hot water was chilled by the refrigerant, so that excessively large amounts had to be used in order to obtain efficient sterilisation.

The ice cream is generally drawn from the freezer at temperatures ranging from 20°-25°F., and then hardened and stored at 0°F. or lower. Hammer (1912), Esten and Mason

(1915), Hammer and Goss (1917), Ellenberger (1919), Fay and Olson (1924), Olson and Fay (1925) and Fabian and Cromley (1933) have shown that there is a gradual decrease in bacterial content during storage at this low temperature, the extent of the decrease depending on the types of organisms present. Weinzirl and Gerdeman (1929), however, found that storage at 14°F or above did not prevent all bacterial multiplication. They suggest that their results furnish at least a partial explanation of the increased numbers of bacteria found in retailers' samples as compared with those from producers. The resistance or development of certain types of bacteria in milk or dairy products held at temperatures between 0° and 20°F. does not seem to have been studied during recent years.

Bacteriological methods of grading.

There are four bacteriological tests available for determining the hygienic quality of ice cream, namely, plate count, coliform test, direct microscopic count and anaerobic spore test. The plate count and coliform test are the ones generally used in this country. Weinzirl and Harries (1928) and Fay (1937) have compared and discussed the significance of these tests in connection with the grading of ice cream, while Fay, Hammer and Fabian (1933) acting as a sub-committee, have reported to the American Dairy Science Association that the plate count and direct microscopic examination seem most suitable, though qualitative methods such as the coliform test and the anaerobic spore test are discussed.

Several types of media have been used in the plating of ice cream, but up to the last three years or so, standard nutrient agar has been most commonly used for routine purposes. Large numbers of pin point colonies have often been noted in low dilutions of ice cream plated (1/10 and 1/100 ml.) while they were not present in proportional numbers or were absent in higher dilutions (1/1,000 and 1/10,000 ml.). Fay (1926) and Fabricius and Hammer (1931) recommend the use of one per cent. sucrose agar as a means of encouraging the growth of these saccharophilic organisms in the higher dilutions. Fay (1937) later made parallel counts using standard agar and one per cent. glucose agar on 271 samples and found the latter medium most satisfactory. Babel (1936) during an analysis of 192 samples of commercial ice cream found tryptone-glucose-skim milk agar to be superior to standard agar or standard agar plus one per cent. sucrose. The former medium gave higher counts and colonies

of greater size than did the latter two media. Robertson (1936) has also summarised comparative data on 412 samples of ice cream. Expressing the average (logarithmic) standard agar count as 100, the tryptone-glucose-skim milk agar count was 116 per cent. Grimes (1936) obtained similar results, while Yale and Hickey (1937) during the examination of 112 samples from twelve manufacturers obtained an average increase in count of 162 per cent. in favour of the tryptone-glucose-skim milk agar.

These results agree with those obtained by a number of investigators in both England and the United States in connection with the bacteriological grading of milk. The yeast-extract milk agar now used in this country for the routine examination of pasteurised milk (Memorandum 1937) should be suitable for ice cream grading. Yale and Hickey (1937) have, however, drawn attention to the possibility that the bacterial flora of ice cream may differ considerably from that of liquid milk, due to its higher sugar content, higher pasteurising temperature, variety of ingredients and low storage temperature.

A number of investigators have studied the effect of temperatures of incubation on the colony counts of ice cream. The plate counts obtained by Buchan (1910) on gelatine incubated three days at 22°C. were on the average over ten times those obtained on standard agar incubated two days at 37°C. Ellenberger (1919) compared incubation at 20°, 30° and 37°C., and found incubation at 20°C. for seven days to give the highest counts, averaging three times those on plates at 37°C Incubation for three days at 30°C. gave counts on the average 2½ times those at 37°C. Ayers and Johnson (1917) found that incubation at 30°C. for five days gave them practically double the counts secured at 37°C. Pederson and Yale (1934) suggest that the optimum temperature for incubation of ice cream plates is somewhat lower than for milk and is probably between 25° and 30°C. Robertson (1936) also observed that incubation at 32°C. gave higher counts than 37°C., whilst Yale and Hickey (1937) support this view. Grimes (1937) states that he is of the opinion that incubation at any temperature between 21° and 30°C. for a period of three to five days may be regarded as most suitable for the estimation of bacteria in ice cream by the plate method.

Though there is considerable criticism of the coliform test as a criterion of the hygienic quality of milk, it should be borne in mind that very few cells of these organisms should survive in ice cream pasteurised at 150°F. for thirty minutes and that they are not expected to develop at the low storage temperature of this product. The coliform test as applied to retail ice cream

should therefore indicate any serious post pasteurisation contamination. While there is some evidence to show that small numbers of coliform bacteria will survive in ice cream, pasteurised at 150°F., their presence in dilutions higher than 1/10 ml. will generally indicate contamination warranting a detailed study of the methods of manufacture and handling.

The direct microscopic examination of ice cream has been used by a number of workers, and Fay (1933) has described a modification of the original Breed method for this purpose. This test can usefully be employed for detecting gross contamination of ice cream or the milk product ingredients.

The anaerobic spore test has been used as an index of manurial pollution of water, milk, milk products and ice cream, but it has not been proved that manure is the only source of this group of organisms. It is a laborious test and requires expensive apparatus and much incubator space—factors that have contributed to its comparative neglect for routine purposes. Weinzirl and Harries (1928) and Grimes (1937) have used this test for the grading of ice cream. The former report favourably on its use whilst Grimes considers that anaerobic spore formers should not be detected in ice cream of good quality.

Bacterial standards.

The number of bacteria in milk and its products has been used for a number of years as an index of hygienic quality, and it is considered that the presence of an excessive number of bacteria in ice cream can be attributed to poor quality ingredients or faulty methods of manufacture and distribution. A good deal of information on the bacterial content of ice cream is now available and it is thus opportune to discuss bacterial standards which may be set up for the guidance of manufacturers and public health authorities. Buchan as early as 1910 suggested bacteriological standards for ice cream, namely, not more than 1,000,000 organisms per ml. capable of growing on standard agar in two days at 37°C., and no coliform organisms to be detected in a smaller quantity than 1/10 ml. Fay and Olson (1924) consider that it is practical to produce ice cream consistently, containing less than 100,000 bacteria per ml., under commercial conditions, by pasteurising at 150°F. for thirty minutes and by using utensils and equipment that have been thoroughly cleaned and steam sterilised. Fabian (1926b) presents data representing the examination of 1,110 samples of ice cream from thirty-six plants—ranging in size from those making a few gallons per week to those

manufacturing as much as 30,000 gallons per day. He believes that a standard agar plate count in two days at 37°C. of 100,000 is a practical standard.

Several countries have recently adopted bacterial standards for ice cream, particulars of which are listed by Anderson (1935). According to Fabian (1935) twenty-six states in America require pasteurisation of the mix or milk products used, and twelve states have established maximum bacterial standards ranging from 100,000 to 500,000 per ml. Grimes (1937) suggests that in the event of bacterial standards being adopted in Ireland, the maximum bacterial count should be 100,000 per ml., and coliform organisms should not be detected in 1/10 ml.

TABLE I.

Raw Ice Cream.

		Colony count (Milk agar) 3 days at 37° C.				
Manufacturer.	*No. of samples examined.*	*Geometric mean count per ml.*	*Per cent. samples with "spreader" colonies dominant.*	*Per cent. Coliform positive samples (+1 10 ml.)*	** Per cent. samples attaining suggested standards.*	*Per cent. Fat. Arith. Mean.*
1	5	4,100,000	60	40	0	2.26
2	17	1,350,000	35	41	12	3.85
3	16	1,580,000	88	75	6	2.95
4	13	2,400,000	0	85	15	4.81
5	4	73,000	0	25	50	3.65
6	9	490,000	0	89	11	2.99
7	8	2,138,000	50	63	12	3.17
8	4	646,000	0	75	25	2.62
9	4	214,000	50	50	25	2.90
10	5	409,000	80	80	20	2.28
11	7	1,020,000	0	100	0	11.14
12	6	1,503,000	100	100	0	6.17
13	3	832,000	0	33	0	2.75
14	3	443,000	0	33	0	3.75
15	3	1,862,000	100	100	0	3.10
16	4	3,311,000	25	100	0	7.53
Mean	111	1,120,000	39	65	11	4.18
Pasteurised Ice Cream.						
17	14	13,500	0	36	64	9.00
18	4	52,480	0	25	50	12.00
19	4	28,510	0	0	50	12.12
20	3	30,200	0	33	33	12.70
Mean	25	20,840	0	28	56	10.48

Suggested standards:—Bacterial count at 37 C. (Milk agar) not to exceed 100,000 per ml. Coliform organisms not to be detected in 1/10 ml, ice cream.

Present work.

A total of 186 samples were taken from twenty retailers during June to September. Eight ounce wide mouthed jars, sterilised in the laboratory, were used for sampling at the retailers premises or from the ice cream barrows. Sixteen retailers manufactured their own produce in small amounts every few days. Three retailers obtained ice cream from large commercial factories, where it was made according to modern methods. One retailer manufactured his own ice cream by modern methods. The results have been grouped throughout according to the method of manufacture.

On arrival at the laboratory the samples were held at 37°C. for thirty minutes and examined immediately on melting. Yeast extract-peptone-milk agar was used for plating, dilutions of 1/10 to 1/10,000 ml. being prepared. The plates were incubated for three days at 37°C though duplicate plates for five days at 22°C. were also put up for a number of samples.

The presumptive coliform test at 37°C. as described in Memo. 139/Foods was used, dilutions of 1 ml. to 1/100,000 ml. being set up and incubated for three days The fat content was determined by means of the Gerber test. The results are summarised in Tables I to V and depicted in the accompanying chart.

TABLE II.
Bacterial count (Milk agar).

Colony count per ml.	*Per cent. samples.*	
	Raw ice cream.	*Pasteurised ice cream.*
0—1,000	0 } 19	4 } 84
1,001—10,000	3	28
10,001—100,000	16	52
100,001—1,000,000	27	16
1,000,001—10,000,000	33	0
10,000,001—100,000,000	18	0
Over 100,000,000	3	0

Discussion.

Sixteen of the manufacturers did not pasteurise the mix, whilst four heated the mix for thirty minutes at 145° to 150°F. The ice cream produced by the two groups is markedly different in bacteriological content, the average (geometric) bacterial content of 111 samples of so called " raw " ice cream being over one million per ml., whereas the average count of 25 samples of ice cream made from pasteurised mix is under 21,000. Colony

counts under 100,000 were recorded for 84 per cent. of the pasteurised samples but only for 19 per cent. of the "raw" samples. The raw ice cream produced by nine manufacturers was characterised by the consistent appearance of "spreader" colonies of aerobic spore forming rods on the milk agar plates.

TABLE III.

Comparison between plate counts on milk agar incubated three days at 37° C. or five days at 22° C.

Dilution.	*No. of Samples.*	*22°/37° C. ratio.* Minimum.	Mean.	Maximum.	*Type of ice cream.*
1/100 ml.	2	0.92	2.20	8.48	Pasteurised
1/1,000 ml.	4	2.06	2.69	4.28	Pasteurised
1/10,000 ml.	15	0.65	4.22	24.82	Raw.
Mean ...	21	—	3.74	—	—

The "spreader" colonies were dominant on plates of all dilutions made on certain samples, and practically all the samples from certain producers showed these characteristic colonies. It is of interest to note that none of the pasteurised ice cream samples contained these organisms. The preponderance of the "spreaders" seems to be associated with poor quality ingredients and unhygienic methods of manufacture. A similar bacterial flora was observed during the examination of samples of highly contaminated sugar, as well as in sterile saline washings of an inefficiently sterilised freezer. It will be observed that their presence was associated with a high total plate count in all cases (Table I). A further study of the nature and source of these spore formers is being undertaken.

A comparison of incubation at 22° and 37°C. (Table III) shows that the colony counts at 22°C. are more than twice those at 37°C. in the lower dilutions (actually all pasteurised samples) and over four times in the higher dilutions used for the "raw" samples.

Coliform organisms were present in large numbers in the unpasteurised ice cream, being detected in 1/1,000 ml. in 84 per cent., and in 1/10 ml. in 65 per cent. of the samples The pasteurised ice cream on the other hand rarely contained appreciable numbers of coliform bacteria, only 28 per cent. showing their presence in 1/10 ml. Some samples taken at Plant No. 17 immediately after pasteurisation of the mix, and after freezing and storing, showed that the coliform organisms content in this case was mainly due to recontamination.

TABLE IV.

Presumptive coliform test.

Coliform content.	*Per cent. samples.*	
	Raw ice cream.	*Pasteurised ice cream.*
Absent in 1 ml.	15 } 35	36 } 72
+ 1 ml	20 }	36 }
+ 1/10th ml.	14	8
+ 1/100th ml.	17	12
+ 1/1,000th ml.	19	8
+ 1/10,000th ml.	11	0
+ 1/100,000th ml.	4	0

Pasteurised milk, according to the prescription of the Milk (Special Designations) Order, 1936, must not contain more than 100,000 bacteria per ml. developing on yeast-extract-peptone-milk-agar incubated for two days at 37°C. It is considered that in view of the higher temperatures used for the pasteurisation of ice cream, and the much lower temperatures at which it is stored and retailed, the following suggested standards would not be too stringent :—

(1) Plate counts at 37°C. not to exceed 100,000 per ml.

(2) Coliform organisms not to be detected in 1/10 ml.

It may be observed that very few of the "raw" ice cream samples attained these standards, but that over half the pasteurised samples did so. The adoption of such bacterial standards would encourage the use of fresh ingredients, efficient pasteurisation and adequate steam sterilisation of equipment.

TABLE V.

Milk Fat Content.

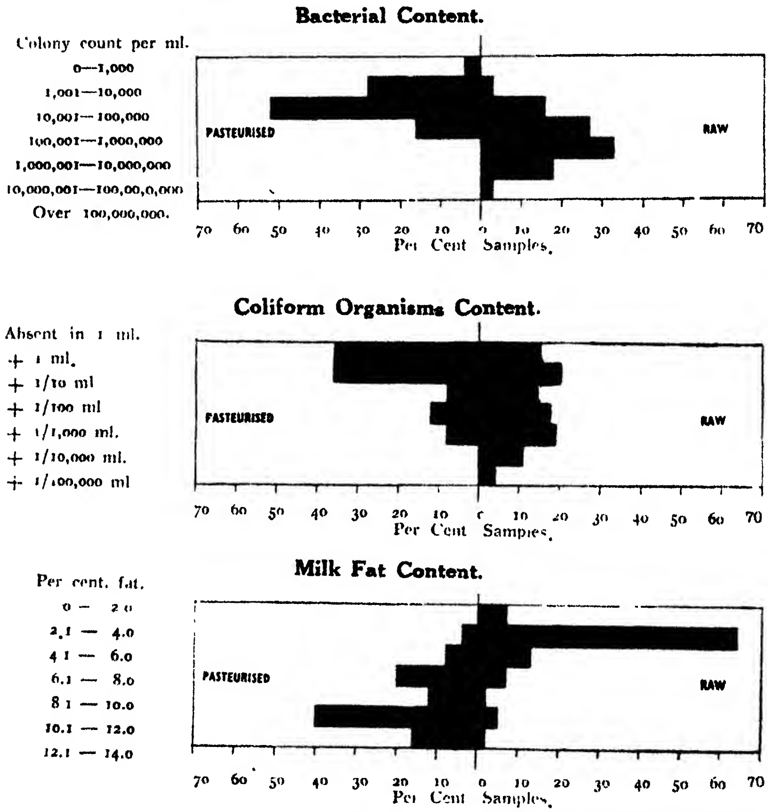
Per cent. Fat.	*Per cent. samples.*	
	Raw ice cream.	*Pasteurised ice cream.*
0— 2.0	7	0
2.1— 4.0	64	4
4.1— 6.0	13	8
6.1— 8.0	7	20
8.1—10.0	2 }	12 }
10.1—12.0	5 } 9	40 } 68
12.1—14.0	2 }	16 }

Legal butter fat standards varying from 8 to 14 per cent. have been in force in the United States for a number of years,

and since 1924 the Ice Cream Association of Great Britain has advocated the adoption of similar standards. The National Farmers' Union, Medical Officers of Health and Sanitary Officers have also from time to time supported them. The standards suggested by these authorities range from 8 to 10 per cent. The results of numerous analyses show that much ice cream

CHART 1.

Comparison of Raw and Pasteurised Ice-Cream Samples.



of low fat content is still being sold. Thierens (1930) found that samples taken in Blackburn contained as little as 0.6 per cent., others contained as much as 28 per cent., with an average of 3.50 per cent. Thomas (1936) found that samples taken from barrows showed an average fat content of 2.50 per cent., varying from 1.65 to 2.80. That sold from shops or cafes gave an average fat content of 8.98 per cent., ranging from 2.64 to 20.0 per cent.

The analyses carried out during the present work show that the majority of the manufacturers produced ice cream with a fat

content of approximately 3 per cent. Only five manufacturers produced an ice cream with a fat content over 8 per cent. If 8 per cent. be taken as a minimum standard for discussion, it will be observed that 68 per cent. of the pasteurised samples attained it, whereas only 9 per cent. of the "raw" samples did so (Table V).

Summary.

(1) A brief review of the literature dealing with the bacteriology of ice cream is given.

(2) The results of the bacteriological examination of 136 samples of ice cream from twenty retailers in a small town are given.

(3) The plate count at 37°C., using yeast extract-peptone-milk-agar as a medium; and the presumptive coliform test were used for grading.

(4) The results of the comparison of incubation of agar plates at 22°C. and 37°C. are also given.

(5) Manufacturers who pasteurised the mix at 145°-150°F. for thirty minutes produced an ice cream far superior to that made by manufacturers who did not pasteurise the mix.

(6) The following bacteriological standards are suggested:—

- (*a*) Plate count on milk-agar at 37°C. should not exceed 100,000 colonies per ml.
- (*b*) Coliform organisms should not be present in 1/10 ml.

(7) Only five manufacturers attained an 8 per cent. fat standard consistently.

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THE USE OF SODIUM CHLORATE FOR DESTROYING SOME PERENNIAL WEEDS.

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Sodium chlorate has been used both as a powder and in solution of various strengths up to 10 per cent. for the control of different weeds. It has been applied for this purpose notably against thistles and bindweed in America, and against a large number of plants by Tincker (1) in England, and others (2). No reference, however, had been seen regarding its use against the perennial weeds which are mentioned below. It is therefore considered that these notes may be of use for the guidance of those who may have to deal with a similar problem in the future.

RAMSONS (*Allium ursinum*). The writer's first experience with this plant was in 1930 in response to complaints about it causing taint in milk and meat on a farm in the Vale of Glamorgan. It is generally found very difficult to uproot the plants as the bulbs are very deep. They recover rather easily after cutting and when situated in woodland or hedgerow this process is rather difficult. In the test made in 1930 the plants grew along hedge banks and to some extent were mixed with the hedgerow bushes. The plants in a strip one yard wide by ninety-six yards long were sprayed with two gallons of a solution made up of 1 lb. sodium chlorate in one gallon of water, that is, a 10 per cent. solution. It was applied with a hand sprayer which deposited the solution in a fine spray, and the leaves were well covered. At the time of application, April 15th, the weather

was fair. The plot was visited on April 24th, when it was noticed that the more exposed and older leaves were more withered and bleached than those in the shade and the younger ones. The flower buds at that time did not appear to have been injured. When the plot was examined a fortnight later there were hardly any ramsons plants left, and in 1931, the plants did not make their appearance at all on the treated plot. It appears therefore, that this is a useful method to use in such situations against these plants. Although the leaves of hawthorn and dog-rose were scorched at the time, no further injury seems to have been done to these plants under the conditions of the experiment. It may also be noted that dock leaves which happened to be treated were thoroughly crumpled up and brown where they were drenched. Both nettles and chervil were blackened, while dog's mercury and yarrow were slightly affected and tor-grass was browned.

Wild Garlic (*Allium vineale*) is a close relation of the above. A farmer tried the above solution on clumps of garlic, but although the plants were scorched a little they soon recovered. A similar experience followed the use of the spray on plants which were grown in a box, the injurious effect soon passing off. Tincker (1) also found that *Allium vineale* was not killed in his experiments by the strongest solution used.

Woodwax (*Genista tinctoria*). This weed, usually called Dyer's greenweed, is common on poor pastures on the hill sides in the neighbourhood of Trellech and other parts of Monmouthshire. On May 30th, 1930, a 10 per cent. solution prepared as in the case of the ramsons, was sprayed on clumps of woodwax in small plots. The plots were visited on July 2nd, when it was seen that the plants had been practically killed, but the grass growing amongst them was also rather parched. It seems that where the weed is thick this method would be useful in reducing it and to prevent seed forming. Probably it would be better to adopt cultural measures coupled with appropriate manuring for permanent improvement.

Butterbur (*Petasites ovatus*). This is a weed usually found in wet places, but in one situation overlying limestone in Gower, the weed had over-run an orchard and was spreading into the adjoining field on apparently dry ground. The occupier of the land had attempted to destroy the plants by cutting at different times, by the application of bluestone solution from a foot-rot bath and an arsenical sheep-dip, without being able to reduce the weed. A large plot was marked out in the field on May 27th, 1937, and was treated with a 10 per cent. solution of sodium

chlorate. The plants in this plot had been partly eaten by sheep when young and the leaves were small, about 5 to 6 inches across with a bud partly opened. The plants in the orchard were larger, the leaves being 12 to 18 inches across and quite covering the ground. The weather at the time of application was sunny with a strong breeze. The previous and following days were also fine. The solution was applied with a watering can so that the leaves were just wetted. It was noticed that the plants were flagging soon after the operation was finished. It was also observed that the docks present were similarly affected. Within two hours of the application, brown spots were noticed on the young leaves in the field. By June 10th, the upper leaves of the plants were completely killed, and in the orchard the treated plants had made no new growth. In the field some new leaves were noticed on a few plants, probably where the treatment had not been thorough. Docks, nettles, creeping and field thistle were also badly damaged. Sheep had access to the plants soon after they were sprayed and devoured them readily without showing any ill effects. Mayweed was injured as well as meadow grass, but the grass recovered gradually. Care was taken not to spray within two or three feet of the fruit trees and no damage was noticed during the season.

HORSE RADISH (*Cochlearia Armoracia*). This plant is common in South Wales, especially on sites of old abandoned gardens from which it tends to spread to neighbouring pastures and, once established, is very difficult to eradicate. In August, 1937, a small-holder in the Aberdare valley suspected that the fibrous leaves of this plant were causing digestive trouble to pigs. He found that continual cutting did not decrease it effectively. He was recommended to apply a 10 per cent. solution of sodium chlorate. This was done and the plants were completely destroyed, together with other weeds in the pig run. No harm ensued to the pigs which were penned on the ground which was treated.

The above notes show that a solution of 1 lb. of sodium chlorate in 1 gallon of water, applied at the rate of about 100 gallons to the acre, either by spraying or sprinkling on the plants so that they are just wetted, will destroy many plants which have strong root systems. Grasses appear to be more resistant than broad-leaved plants. The cost of material works out at about 40 shillings per acre of ground covered. It is possible that weaker solutions would be effective in certain circumstances but further trials are required to determine this point as well as the best time of application.

Sodium chlorate solution is safe to stock in a small quantity. While care should be exercised in the storage and handling of the material on account of the danger of fire, no accident has happened in the course of its application in this country, but clothes wetted with the solution should be discarded as soon as possible and washed out before drying, as material soaked with the salt is very inflammable when dry.

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SOME FACTORS GOVERNING THE INCIDENCE OF HELMINTH PARASITES IN THE DOMESTIC DUCK.

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Introductory.

The four kinds of helminth parasite that infest the domestic duck are Trematodes (flukes), Cestodes (tapeworms), Nematodes (roundworms), and Acanthocephala (thorny-headed worms), the common species of these groups being all parasites of the intestinal tract.

Like the common Liver Fluke of sheep and cattle, all species of Trematodes require a particular snail in which to develop outside the final host; the absence of this species of snail makes it impossible for the parasite to survive. Snails in their turn are dependent upon a natural supply of lime for the formation of their shells, so that districts deficient in their natural calcium resources can support but a poor population of freshwater snails. In such areas the numbers and variety of Trematode parasites are limited owing to the paucity of suitable snail hosts.

The Cestodes also utilise small invertebrates for their early development, but the invertebrate in this case is seldom a snail. Most of the tapeworms of aquatic birds develop in water-fleas and aquatic insects, and the infection of the bird takes place when these organisms are swallowed with the food.

Nematodes may have a direct life-history, infection occurring through the swallowing of helminth eggs in the water or with the food, or, like the Acanthocephala, they may require the

existence of a suitable invertebrate to act in the capacity of a second host.

The Scope of the Present Enquiry.

During the last half-century, the internal parasites of the domestic duck have received considerable attention from systematic zoologists, whose investigations, however, have never been conducted with an economic bias, and whose results have never been brought to bear on methods of practical stock breeding.

It was the object of the present writer to attempt a correlation of the incidence of helminth parasites with the geographical position and physical nature of the feeding-grounds frequented by the birds.

Advantage was taken of the opportunity of collecting the intestines of birds slaughtered for the Christmas market in 1935 and 1936; the data from these investigations are incorporated respectively in Tables I and II.

TABLE I.

Showing the Occurrence of various Helminths in 14 ducks *Anas boscas dom.*, examined at Aberystwyth, December, 1935.

Host No.	*TREMATODA.*	Nos. of CESTODA.					*NEMTODA.*	*ACANTHOCEPHALA. Polymorphus boschadis.*	*Name of Farm.*	*Feeding Range.*
		Ophryocotyle sp.	*Hymenolepis coronula.*	*Hymenolepis gracilis.*	*Aploparaksis furcigera.*	*Fimbriaria fasciolaris.*				
1.			25	10		2				
2.		1			7					
3.				75	5					Stagnant
4.			25	50	4	1		2	A	Water.
5.										
6.				40		2				
7.						3		1		
8.									B	
9.						1		3		
10.										Water.
11.				8					C	Running
12.										
13.										
14.									D	

The fourteen birds examined in 1935 (Table I) and the fifteen examined in 1936 (Table II) were all bred on seven different farms (A, B, C, D, E, F, and G) situated in the parish of Cilcennin, some fifteen miles south of Aberystwyth, and bordering the valley of the Aeron. In six of these farms (B to G) the birds gained access to rapid streams, whilst in the one

TABLE II.

Showing the Occurrence of various Helminths in 15 ducks, *Anas boscas dom.*, examined at Aberystwyth, December, 1936.

Host No.	*TREMATODA.*	*Nos. of CESTODA.* *Ophryocotyle sp.*	*Hymenolepis coronula*	*Hymenolepis gracilis.*	*Aploparaksis furcigera*	*Fimbriaria fasciolaris.*	*NEMTODA.*	*ACANTHOCEPHALA. Polymorphus boschadis.*	*Name of Farm.*	*Feeding Range.*
1				10		9			A	Stagnant Water.
2					9	2				
3				14		3		2		
4					1	2				
5				1	4	3				
6				1		1		1		
7									B	Running Water.
8										
9									E	
10						3				
11				2					F	
12						1				
13										
14										
15									G	

farm A, they were fed exclusively in a duck-pond maintained by several springs near the pond site; these springs afford a constant supply of water throughout the four seasons.

Taking the data of Tables I and II together, out of seventeen birds fed in running water, six were infested with helminths of one species or another, giving an infestation of 35 per cent.; the number of parasites from each infested host was in all cases particularly small. The species recorded were

Cestodes (tapeworms):

Hymenolepis gracilis (Zeder 1803).

Fimbriaria fasciolaris (Pallas 1781).

Acanthocephala (thorny-headed worms):

Polymorphus boschadis (Schrank 1788).

Out of twelve birds collected from A, a total of eleven birds contained helminth parasites, giving an approximate infestation of 92 per cent. In the majority of cases a considerable number of parasites was derived from each infested bird, whilst four hosts in particular (Table I, Nos. 1, 3, 4, and 6) harboured large numbers of worms that must have caused considerable physiological drain if not mechanical obstruction to the passage of food through the intestine. The species recorded from A were

Cestodes (tapeworms):

Ophryocotyle sp.

Hymenolepis coronula (Dujardin 1845).

Hymenolepis gracilis (Zeder 1803).

Aploparaksis furcigera (Rudolphi 1819).

Fimbriaria fasciolaris (Pallas 1781).

Acanthocephala (thorny-headed worms):

Polymorphus boschadis (Schrank 1788).

The absence of Trematodes (flukes) in the birds examined at Aberystwyth is a notable feature which will be discussed in a later part of this paper.

The effect of Stagnant and Running Water on Parasitic Infestations.

When the two sets of data recorded above are compared it is readily seen that the birds fed in stagnant water yielded a greater variety of helminth species, whilst the infestation was generally considerably higher than with birds fed in running water. On all farms the ducks received no extra feeding to supplement their own foraging, with the exception of the last few weeks, when they were allowed a small ration of maize for "fattening off." In all cases also, the birds were in the region of seven months old, so that the differences in the nature and extent of their helminthic infestations cannot be traced to differences of age or of dietary treatment.

The absence of Trematodes and Nematodes makes it impossible to correlate their infestations with the type of feeding ground.

The species of Cestodes and Acanthocephala here recorded are mainly dependent upon small Crustacea (water-fleas and freshwater shrimps) for the completion of their life-histories. *Hymenolepis coronula* and *H. gracilis* spend their larval stages in

species of Cypris, Cypria, Cyclocypris, Cyclops, and Diaptomus, whilst *Fimbriaria fasciolaris* is known to develop in *Diaptomus vulgaris.* The Acanthocephalan *Polymorphus boschadis* utilises the freshwater shrimp, *Gammarus pulex*, as its intermediate host.

The rate of infection of birds with these parasites depends on the relative abundance of water-fleas and shrimps in the waters they frequent, and on the extent to which these invertebrates are infested with helminth larvae.

It is evident that the establishment of colonies of small invertebrates in rapid streams is attended with considerable mechanical difficulty, whilst the stagnant water of the farmyard pond, with its abundance of algal vegetation, affords ideal conditions for the growth of such colonies. Furthermore, the birds in their constant habitation of these ponds must effect thorough contamination of the water with the eggs of helminths, which in turn ensures a high percentage of infection of the invertebrate colonies with their larvae. The constant and rapid movement of the water in a stream, apart from retarding the growth of the Crustacean population, exercises a profound effect on the rate of ingestion of eggs by Crustacea. The resultant infection of stream-inhabiting birds is consequently reduced, as is indicated in the above Tables.

These results suggest that, within a particular area of uniform geological formation, the single physical condition of the movement of the surface water is the limiting factor in the distribution of the helminth parasites of the domestic duck. Its action is two-fold; firstly, it controls the numbers of the invertebrate second hosts, while secondly it governs the distribution of helminth eggs and consequently the rate of their ingestion by the invertebrate hosts.

In larger areas with varying types of geological formations, other factors are introduced whose importance masks the effect of the movement of surface waters. These factors are considered in the following pages in relation to the distribution of the helminth parasites of the duck in Britain.

The distribution of Helminth Species Parasites in the Domestic Duck in Britain.

In view of the results of the writer's observations at Aberystwyth, the following Table III was compiled to attempt some generalisations regarding the factors governing helminth distribution of the domestic duck in the whole area of Britain. The available data relating to Britain are, however, regrettably scanty, the only references being those of Lewis (1928), Foggie

(1938), and Walker (1937). These data, together with the results of the writer's work at Aberystwyth, are tabulated below as records for different parts of Britain.

TABLE III.

Showing the Distribution of Species of Helminths recorded from the domestic duck in Britain.

Area.	*TREMATODA.*	*CESTODA.*	*NEMATODA.*	*ACANTHO-CEPHALA.*
South of England.	*Strigea tarda* *Notocotylus attenuatus* *Typhlocoelum flavum* *Psilochasmus oxyurus* *Echinostoma sp.*	*Hymenolepis megalops*	*Capillaria anatis* *Tropisurus fissipinus*	—
Severn Valley.	*Strigea gracilis*	—	—	—
Mid and South Wales.	—	*Ophryocotyle sp.* *Hymenolepis gracilis* *Hymenolepis coronula* *Hymenolepis sp.* *Fimbriaria fasciolaris* *Aploparaksis furcigera*	*Capillaria anatis* *Porrocaecum crassum*	*Polymorphus boschadis*

It will be noticed from Table III that the data so far obtained suggest either the absence or a very limited occurrence of duck Trematodes in mid and south Wales, whilst they are represented by *Strigea gracilis* in the Severn Valley. The data given by Foggie (1933) show that in the south of England the Trematodes are represented by five species, all five having been collected from only nine birds examined. The Cestodes on the other hand are represented in mid and south Wales by six species, whilst in the data given by Foggie for English birds they are

represented by only one species. Of the Nematodes, *Capillaria anatis* has been recorded from South Wales and the South of England; *Porrocaecum crassum* is known to occur in the Gower Peninsula in South Wales, whilst *Tropisurus fissisipinus* has been collected in the south of England. The writer has recorded the Acanthocephalan *Polymorphus boschadis* from the Aberystwyth area of Wales.

These data are admittedly all too scanty, yet they suggest a distributional picture whose distinctive feature is the predominance of Trematodes in the birds of southern England and a predominance of Cestodes in the birds of mid and south Wales. The reason for this difference is indeed not far to seek. Owing to the geological formation of west Wales—consisting of Silurian rocks of the lower Valentian series—the rivers and springs are all seriously deficient in lime. This deficiency effects a serious limitation of the variety and numbers of freshwater snail populations, which in turn brings about an extreme paucity of Trematodes, whose life-cycles demand a molluscan second host. Contrast with this the parts of England where large numbers of snails of various species can derive the necessary lime for their shells from the abundant natural supply in the soil. Lime deficiency, of course, does not affect the vast majority of tapeworm species, whose second hosts are generally either Crustacea or insects, seldom molluscs.

Conclusions.

With regard to the subject of tapeworms in poultry, the Ministry of Agriculture and Fisheries Leaflet No. 80 states that "Ducks . . . . . are rarely affected, and may harbour many worms without apparent harm." While future work may show that losses through direct mortality caused by tapeworms in these birds are indeed extremely low, nevertheless, large numbers of worms in the intestines of birds—whether flukes, tapeworms, roundworms, or thorny-headed worms—must surely cause a constant physiological drain that works towards diminished vigour in a healthy stock.

In the past, little or no attention has been paid to the economic biology of the helminths of Christmas poultry, and the present enquiry is an attempt at elucidating some of the factors governing the distribution of these parasites under natural conditions. A Table of data for the area of Britain shows that the nature of the geological formation is responsible for determining the type of the prevalent species of parasite. Thus flukes are prevalent in areas where the supply of natural lime allows of a

prolific population of freshwater snails, whereas in parts such as Wales, weher the surface waters are deficient in lime, as far as available data show, they are absent.

Provided that the geological formation is uniform, it would seem that the rate of movement of the surface waters is the important factor in determining the nature and extent of helminthic infestations. Rapid flowing streams dispose of the helminth eggs passed out with the droppings of birds, whilst the stagnant waters of farmyard ponds retain them for ingestion by the invertebrate second hosts. The movement of the water in a stream, furthermore, hinders the proliferation of colonies of these invertebrates, whilst the pond affords ideal conditions for their development.

Thus in two different ways the movement of water in a stream militates against the spread of helminthic infestations, and the breeders of water-fowl would be well advised to resort to streams for feeding grounds for their stock rather than to utilise the stagnant waters of duck-ponds, where ideal conditions for the perpetuation of helminth diseases prevail.

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ABSTRACTS, REVIEWS, AND BIBLIOGRAPHICAL NOTES.

ANIMAL NUTRITION.

Abstractors:

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Farm Livestock; The Feeding of

J. C. B. ELLIS, M.A. Crosby Lockwood, 15/-.

This is a very valuable addition to the list of text books available for the use of agricultural students and others interested in the feeding of livestock. The opening chapters deal with the composition and constituents of foods, the digestion and utilization of food by the animal, and the various methods used to ascertain the daily requirements of different classes of animals for both maintenance and production. Particular attention has been given to dry matter, starch equivalent and protein equivalent requirements for different purposes under a variety of circumstances. In the case of the ordinary farm when these are satisfied, the author considers that apart from a few particular circumstances, there is no need to become unduly alarmed through any probable deficiency of minerals and vitamins.

Later chapters deal with the common types of home-grown and purchased feeding stuffs, but no reference is made to the risks involved in the feeding of certain foods to some classes of animals, *e.g.*, undecorticated cotton cake to young cattle, and mangolds to male sheep. A full treatment, however, is accorded to the preservation of green fodder as hay, silage and artificially dried grass, together with a thorough discussion of their respective nutritive values. The author indicates the possibilities of wide variations in the nutritive values of different foods and the consequent difficulties of accurate rationing on the farm.

The Welsh farmer would have found this section of the book of much greater interest if the variations in composition and nutritive value of the different species of grasses and clovers, the different types of hay and roots, and of milk, had been dealt with in the light of recent work.

The final portion of the book is devoted to the practical rationing of farm stock and deals fully with cattle, sheep, horses, and pigs, concluding with a short chapter on poultry. For all these the author states the daily requirements and then proceeds to calculate a variety of rations appropriate to different conditions. For the practical man, it might have been better if the treatment of this section of the subject had been somewhat less mathematical, and the figures in the calculations had been used with a greater degree of uniformity. In any case the calculated figures demand too much precision in view of the practical issues involved in the rationing of farm stock, especially with animals which are not dieted individually, but are rationed in groups or bunches

under conditions where the appliances for mixing, weighing and distributing are often extremely crude. As indicated by Professor Scott Watson in his foreword, it is doubtful whether, after all, the precision of the scientist will produce as satisfactory results as the " eye of the master."

The various methods of rationing are very clearly illustrated in the case of calf feeding, dairy cow feeding and pig feeding, and in this direction the book is well in advance of previous publications on the subject. In all these, common sense methods are advocated, and the author stresses the importance of studying the individuality of the high producing animals in particular, under the stockman's care, and to make use of home-grown foodstuffs as far as possible. In the chapter on pigs the same outlook is maintained and farm pig feeding methods are recommended, instead of the recent tendencies to feed pigs on factory lines. The belief in outdoor breeding and rearing of pigs is undoubtedly sound in practice, and the variations in the rations of porkers and baconers with size and age is equally a sound policy. It may be that the author considers only ideal conditions of management, and for that reason omits to deal with common ailments of digestion so prevalent in many districts. A section on such ailments would have added considerably to the value of the work.

The book can be strongly recommended to students of Agriculture, but it appears to be rather beyond the capacity of the practical stockfeeder who has received no previous training in Agricultural Science. However, the stockfeeder may with advantage study the more practical portions of the book.

It is unfortunate that the methods of comparing foods on the basis of unit prices of sta h equivalent are not dealt with more fully, and that the seasonal variations in the current prices of these commodities are not mentioned. It would also have been an advantage had reference been made to the important question of compensation for manurial residues of purchased foods.

In view of their practical importance, more space might have been given to the discussion on minerals and vitamins, yet one feels with the author that the over emphasis of the niceties of balancing food is unnecessary when one considers the usual rough and ready methods practised on the farm. In this respect the author joins those who advocate the more natural methods of stock feeding, rather than follow the more and more artificial devices.

The book is lucidly written and the illustrations and photographs provide the stockfeeder with information regarding up-to-date appliances and equipment to assist him in the scientific rationing of his stock.

R.P.

Fasting Metabolism; A Study of the—of Various Breeds of Hog.; III. Metabolism and Surface Area Measurements.

THOMAS DEIGHTON. *J. Agr. Sci.* (1937), 27, 317-31.

Actual and theoretically computed average growths agree in the case of eleven pigs treated in an exactly similar manner. Individual growth curves showed no such agreement. This is considered to strengthen the evidence for the previously stated view that nett energy is a statistical rather than a physiological constant

R.O.D.

T

Fowl; A Note on the Effect of different Cereals in the Fattening Ration on the Composition of the Body Fat of the

E. M. Cruickshank. *J. Agri. Sci.* (1937), 27, 309-15.

Over a twelve day fattening period the use of maize in the poultry-fattening ration has no detrimental effect on the consistency of the body fat. When fattening is rapid and live weight gains are satisfactory the type of fat deposited is harder than that laid down on a normal ration containing mixed cereals and a protein supplement. R.O.D.

Hay; The Time of Cutting—, and the Losses entailed during Haymaking.

S. J. Watson, W. S. Ferguson and E. A. Horton. *J. Agr. Sci.* (1937), 27, 224-58.

Experiments carried out from 1930-1935 are described. These investigated the composition, digestibility and yield of meadow hay cut at a normal time, and also of hay cut some 3-5 weeks earlier. The ordinary hay yielded 249 lb. per acre more starch equivalent and 47 lb. less protein equivalent than the early hay. In 1935 a comparison was made of two methods of making seeds hay. One method was ordinary windrow drying, and the other the tramped heap or pike. The piked hay gave a greater yield of starch equivalent and protein equivalent.

R.O.D.

Meat Meal; The Composition and Digestibility, when fed to Pigs, of three Grades of—of widely differing Fat Content

H. E. Woodman and R. E. Evans. *J. Agr. Sci.* (1937), 27, 465-73.

All three grades of meat meals investigated had a very high digestibility. The results suggest that "de-greasing" with petroleum benzine may result in a distinct lowering of the digestibility of the meal.

R.O.D.

Mineral Mixtures; Does the Calcium or Phosphorus Content of common —conform to Experimental Findings?

G. Bohstedt. *Proc. Amer. Soc. Animal Prod.*, Dec. (1936), 272-8. (Univ. Wisconsin).

In rations for pigs, consisting mainly of cereals, if extra minerals are required to adjust the Ca : P ratio of the diet, it is usually calcium carbonate which is required and not bone meal or other phosphorus containing minerals. In rations for dairy cows on the other hand, which are usually high in calcium, bone meal or other high phosphorus compound is required to adjust the balance. R.O.D.

Phosphorus for Animals: A review of the Experimental Work with Phosphate in Montana, 1928-35.

J. R. Green. *Montana Agric. Exp. Stat. Circular* No. 148 (1936), 11-16.

A series of tests indicated that more phosphorus was assimilated by cattle fed monocalcium phosphate than by those fed bone meal and that it was the cheaper phosphorus supplement. The proportion of monocalcium phosphate included in the mineral mixture depended on a number of factors such as age, condition, feeding and management of the cattle. R.O.D.

Pig Feeding Experiments; A Comparison of restricted Wet Feeding with unrestricted Dry Feeding.

R. G. BASKETT, R. W. HALE and G. L. GRAY. *J. Min. Agric.* N. Ireland (1937), 5, 1-8.

The results of these experiments show that there was a significant difference in rate of growth in favour of the wet restricted feeding of rations containing either pollards or ground wheat compared with similar rations fed dry and unrestricted. This advantage held in the meal consumption per lb. live weight increase and also for the bacon carcase grading. R.O.D.

Pig; The Nutrition of the Bacon—

II. The Influence of High Protein Intake on Protein and Mineral Metabolism.

H. E. WOODMAN, R. E. EVANS and W. G. TURPITT. *J. Agri. Sci.* (1937), 27, 569-83.

Information is derived from these investigations regarding the retention of nitrogen, lime, phosphoric acid and chlorine. The values for nitrogen retention enabled a correct prediction to be made of the relative leanness of the bacon carcasses. The results suggest that the requirements of the bacon pig for protein, lime and phosphoric acid do not fall off during growth from weaning to slaughter The results of palatibility tests of the "green" bacon suggest that the retention of 5 per cent. of white fish meal in the ration right up to slaughter may be attended with the risk of production of slight fishy taint.

R.O.D.

Poultry; The Digestion of Huskless Oats by

F. E. MOON and BRYNMOR THOMAS. *J. Agri. Sci.* (1937), 27, 458-64.

The starch equivalent of huskless oats when fed to poultry proved to be substantially higher than that of Victory. The former variety has been shown to bear a closer resemblance to wheat, in respect of starch equivalent and digestibility, than to any of the common oat varieties. It is suggested that if huskless oats can be grown successfully on a commercial scale, a new and valuable feeding stuff will become available. R.O.D.

Poultry; Digestibility Trials with

VII. The Digestibility of Wheat Offals, with a Note on the apparent Discrepancy between the Digestibility Coefficients and Nutritive Value of these Products.

VIII. The Digestibility of dried molassed Sugar-beet Pulp.

E. T. HALNAN. *J. Agri. Sci.* (1937), 27, 126-42.

The chick feeding experiments indicate that from a growth standpoint, wheat by-products such as bran and weatings are better than wheat itself. The inclusion of weatings in a chick mixture to an extent exceeding 40 per cent. would appear to be inadvisable owing to its inherent tendency to clog the beak, a tendency that is absent both in the case of bran or coarsely ground wheat. The results obtained indicate that a mixture of bran and middlings forms a biologically better balanced food than either of these foods fed separately.

It is concluded from the experiments on sugar-beet slices that these are unsuitable for poultry-feeding, except in times of scarcity of carbohydrate containing foods. R.O.D.

Sheep Nutrition;

I. Measurements of the Appetites of Sheep on Typical Winter Rations, together with a critical study of the Sheep-Feeding Standards.

H. E. Woodman, R. E. Evans and A. Eden. *J. Agr. Sci.* (1937), 27, 191-211.

From these feeding trials with sheep it is found that the standards of appetite in terms of lb. dry matter proposed by Prof. T. B. Wood are uniformly too high. A table embodying a revision of Prof. Wood's feeding standards for sheep is included in the paper.

II. Determination of the amounts of grass consumed by sheep on pasturage of varying quality.

ibid. 212-23.

A technique for measuring the appetities of sheep on pasture is described. Results are given to show that sheep consume a bigger ration, in terms of lb. dry matter, when on pasture than when subsisting out-of-doors on the winter type of diet composed of hay, swedes (or kale) and concentrates. This distinction is most marked with young leafy pasturage at its best, and the increased appetite is to be attributed to the superior palatability of the young grass. R.O.D.

Silage; A Study of the Chemical and Bacteriological Changes occurring in Grass Silage.

L. A. Allen, J. Harrison, S. J. Watson and W. S. Ferguson. *J. Agri. Sci.* (1937), 27, 271-93.

Producion of good silage appears to depend largely on the early conversion of the available carbohydrate to lactic acid, so that in the later stages of ripening the obligate anaerobes find supplies of carbohydrate restricted and the pH unfavourable for development.

R.O.D.

Silage; Experiments on making Hay and

N. A. Ollsen, H. W. Eskedal, P. S. Østergaard and K. Rottensten. *172nd Rep. Res. Lab. Roy Vet. Agric. Coll Copenhagen* (1937).

The results of 15 experiments in hay and silage making (clover grass mixture cut at early flowering) during the period 1931-6 are described. Loss of dry matter and crude protein from hay was slightly greater than from A.I.V. silage, but on the other hand quantities of the silage had to be discarded because of spoilage at the surface and sides of the silo. Losses from sugar silage were considerably greater than from A.I.V. silage.

Feeding trials with cows showed A.I.V. silage to be superior to sugar silage and hay. R.O.D.

Silage; Grass—. A comparison of the changes involved in the Ordinary, Molasses and A.I.V. processes.

W. Morley Davies, G. H. Botham and W. B Thompson. *J. Agri. Sci.* (1937), 27, 151-61.

Of the three processes it is concluded that the A.I.V. presents more difficulties in farm proctice than the other two. There appears every reason to encourage the use of molasses. R.O.D.

Silage; Legume—for Dairy Cows

C. C. HAYDEN and OTHERS. *Bull. Ohio Agric. Exp. Stat.* (1937), 22, 21-7.

The preparation of legume silage by adding molasses, by the A.I.V. method and without any special treatment is discussed. The results showed that on a dry matter basis there was little difference in the feeding value, as measured by milk production of the three types of silage. The carotene, however, was much better conserved by the A.I.V. method. R.O.D.

Silage; The Chemical Composition of grass

S. J. WATSON and W. S. FERGUSON. *J. Agri. Sci.* (1937), 27, 1-42.

A short account is given of the main changes which take place during the ensilage process, and details are given of the methods of analysis used. Though the ordinary process of silage making may be adequate for material at a fairly advanced stage of growth, it is not suitable for high-protein silage. To obtain greater certainty of first class silage, molasses or acid should be added during the filling of the silo, due precautions being taken in the packing of the material.

R.O.D.

Silage; The effect of the addition of various materials and Bacterial Cultures to Grass—at the time of making on the subsequent Bacterial and Chemical changes.

L. A. ALLEN, S. J. WATSON and W. S. FERGUSON. ibid 294-307.

The addition of soluble carbohydrate to grass silage at the time of making may be beneficial by encouraging the formation of lactic acid which reduces the pH to a low value. Care must be taken to avoid the simultaneous inclusion of a large mixed flora which may develop subsequently in a way which is detrimental to the predominance of the lactic acid fermentation. Experiments so far have indicated that molasses is a suitable source of carbohydrate. The subsequent development of lacto-bacilli may be further ensured by inoculating the molasses with a suitable culture. R.O.D.

Silage; The sources of Dry Matter and digestible Nutrients in low temperature—with and without added Molasses or Mineral Acids.

S. J. WATSON and W. S. FERGUSON. ibid. 67-107.

A series of experiments extending over four years to measure the losses in different types of silage are described. It is concluded that although the A.I.V. process gives silage with the lowest losses, the advantage over the molasses process is not sufficient to justify the general application of the former. With material at an advanced stage of maturity the ordinary low temperature process is quite adequate.

R.O.D.

Swine; The Calcium and Inorganic Phosphorus Content of the Blood Serum of Swine.

E. H. HUGHES. *J. Agr. Res.* (1936), 53, 267-79.

The serum calcium and inorganic phosphorus of the young pig was higher than for the older pig or the adult hog. The serum calcium of the blood of the sow immediately before and after farrowing was higher, and the inorganic phosphorus slightly lower, than the mean for non-pregnant sows of the same age.

The calcium content of the serum depended to a large extent on the calcium supplied in the ration. R.O.D.

Vitamin D; Comparison of Cod-Liver Oil and Ultraviolet Irradiation as sources of Vitamin D for confined laying Hens.

R. B. Nestler. *J. Agr. Res.* (1937), 54, 571-82.

The results show that 2 per cent. of cod-liver oil added to a good laying diet for strictly confined birds is superior, as a source of vitamin D, to ultraviolet irradiation for 15 minutes daily with a carbon arc.

R.O.D.

DAIRYING.

Abstractor:
G. T. Morgan, N.D.A., N.D.D.

Milk and Milk Products; The Handling of

Ministry of Agri. Bulletin No. 31 (1937). H.M.S.O. 2/- net.

The fifth edition of this Bulletin based on work of the National Institute for Research in Dairying contains sections dealing with Clean Milk Production, Pasteurisation, Cheese, Faults in Milk and Dairy Products, Bacteria in Milk and Milk Products, Bacteriological Examination of Milk, Bovine Tuberculosis, and the Nutritive Value of Milk, including material not previously published.

The publication will have a particular appeal to the student and will also be welcomed by all sections of the industry.

ENTOMOLOGY.

Abstractor:
J. R. W. Jenkins, M.Sc., University College, Aberystwyth.

British Woodlands; Insects of the

R. N. Chrystal. Demy 8vo. 338 pp., 33 pls. London: F. Warne & Co., Ltd. (1937), 7/6 net.

This book is intended primarily for foresters, and deals in a practical manner with the insects associated with British forest and ornamental trees. In the first portion, an account is given of insect structure, metamorphosis, and classification. There follow descriptions of the structure and bionomics of the more important pests, which are classified under orders, and divided into sub-sections, according to the nature of the damage. The final portion deals with the study and collection of insects; conditions favourable to epidemic attack; and different methods of control. The book concludes with two appendices, one of which gives specific descriptions of the pests already dealt with, and lists of their food plants, and in the other, the insects are classified according to the nature of the damage caused.

J.R.W.J.

Fruit and Hops; The Pests of

A. M. Massee. Demy 8vo. 294 pp., 27 pls., London: Crosby, Lockwood & Sons Ltd. (1937), 15/- net.

This work, which is essentially practical in outlook, satisfies a long felt need, in that no textbook on the subject has appeared since

Theobald's *Insect Pests of Fruit* was published in 1909. The book is divided into sections, each of which deals with a separate crop, and covers means of identification, bionomics, and methods of control, of each pest of that crop. Abundant cross references, and a bibliography of appropriate literature are provided. Of especial value to growers, in that they are a material aid to identification, are the numerous illustrations of the pests themselves and/or the damage they cause. Sections are also devoted to harmless and beneficial insects found in orchards, and to the preparation, application, and effect of insecticides. The book concludes with a chapter on spraying equipment and its uses, contributed by J. Turnbull. J.R.W.J.

Garden Plants; Pests of Ornamental

G. Fox Wilson. *Ministry of Agri. Bulletin* No. 97, 128 pp., 36 pls., London: H.M.S.O. (1937), 3/6 net.

The publication deals with the control of the common pests of flowering plants, ornamental trees, shrubs and lawns. The first part is devoted to a general consideration of control methods, while the second describes the specific measures to be adopted against such general feeders as Slugs, Woodlice, Wireworms, etc. The third section is devoted to the specific control of pests attacking plant associations such as the Rose Border, Herbaceous Border, Bulbs and Corms, etc., etc.

J.R.W.J.

Household Ants; On the Control of

H. W. Thompson and L. R. Johnson. *Bull. Ent. Res.*, *27*, *pt* 3 (September, 1936).

The authors discuss the control of ants which invade houses, with special reference to *Monomorium pharaonis* L. and *Lasius niger* L. The destruction of nests in houses is difficult, if not impossible, owing to the fact that they are usually situated near ranges, boilers, etc., where destruction would involve considerable structural interference. Trapping by means of sponges soaked in syrup gave a certain degree of success, but did not exterminate the colonies, but in several cases of severe infestation, the authors obtained complete control by means of a *thallium sulphate* and syrup bait enclosed in slotted pill box containers.

J.R.W.J.

Leaf Roll; the Spread of in the Field. A Ten Years' Experiment on

P. A. Murphy and J. B. Loughnane. *Sci. Proc. Roy. Dublin Soc.*, *N.S.* *21*, *No. 50*. Dublin (August, 1937).

The results of this series of experiments, which were carried out in County Dublin, on the spread of Potato Leaf Roll in the field in relation to weather and aphid population, lead the authors to the following conclusions. In an average year, no plant separated from the source of infection by less than 80 inches along the drills, and 50 inches across them, is likely to escape infection, and the chances of infection are slight in plants separated by more than 21 feet along the drills and 10½ feet across. The greater part of the infection appears to occur from the end of May to the beginning of July, and it was noticeable that the weather conditions during this period had a very considerable effect upon the spread. Conditions which gave maximum infection were normal June rainfall and temperature, allowing rapid plant growth and aphid increase, while moderate infection occurred in those years in which the

June weather was warmer and drier than normal. These conditions, while on the whole favouring aphid increase, tend to ripen the plants prematurely, and thus reduce infection. It is considered that since the June climate of eastern Ireland is normally favourable to infection, the general absence of Potato Leaf Roll in the field must be due to a scarcity of the winter hosts of the insect vector, *Myzus persicae*.

J.R.W.J.

Seed in Herbage and Forage Crops; Insects and other Pests injurious to the Production of

H. F. BARNES. *Bull. Herb. Publ. Ser. No. 20* Aberystwyth (June, 1937).

This bulletin, which summarises the information available regarding the pests concerned, is divided into two portions, one of which deals with grasses, and the other with leguminous crops Each part deals with the pests which reduce seed production indirectly, by interfering with the growth or general health of the crop; with those pests which cause direct loss by attacking the inflorescence or developing seed; and with those insects which are potential pests of the future. For each pest, the following information is given :— Present distribution, with indications where applicable, as to possible further spread; the nature of the damage caused; the characters by which it may be recognised; and methods by which it may be controlled. The bulletin concludes with indices of crops and pests. J.R.W.J.

LIVE STOCK.

Abstractors:

A. D. BUCHANAN SMITH, M.A., B.Sc., F.R S.E., Institute of Animal Genetics, University of Edinburgh.

and

Professor R. G. WHITE, M.Sc., University College, Bangor.

Ayrshire Breed; The

A. D BUCHANAN SMITH. (1937). *Trans. High. & Agri. Soc. Scot., 49*, 73-110.

This article deals with the origins and the history of the Ayrshire breed, and also covers modern developments in Scotland and overseas. In discussing the development of the breed the author points out how it has been divided into show and production types, and states that while both have been carried to extremes, the fusion of the types has ultimately benefited the breed.

The article deals with the breed in America, Australia, Africa, and Scandinavia. In Norway, Sweden, and Finland, the Ayrshire is the predominant breed of dairy cattle. Emphasis is laid upon the importance of longevity in the cow. A.D.B.S.

Bacon Hog; Some Observations on Carcase Quality in the

R. D. SINCLAIR and J. ALLAN MURRAY. (1935). *Sci. Agri. 16*, 169-174.

This paper deals with various aspects of the quality of the carcases from bacon pigs. Five litters, two of which were purebred Tamworths, and the remainder Yorkshires (Large Whites) were raised under similar

environmental conditions, and their carcases examined. The difference in average length was not noticeable, but a definite relation was obtained between the weight of the ham and shoulder, and this was uniform as between litters. Depth of back fat and thickness of belly varied considerably. Litter trends were in evidence in that certain litters showed a thick belly, while others lacked this. One litter was particularly good, having low back fat and high belly measurements This litter also showed the highest percentage of lean.

In another series of measurements the authors were able to obtain a definite correlation between certain body and carcase characteristics based on 350 carcases.

Carcases were divided into shoulder, middle, and ham. The authors conclude that the ideal condition is 25 per cent. shoulder, 50 per cent. middle, and 25 per cent. ham. The average for the 350 carcases was 28.5 per cent. shoulder, 47.5 per cent. middle, and 24 per cent. ham.

On another series, on 106 carcase measurements, a positive correlation of + .88 was obtained between the percentage of lean meat and the percentage of ham. As the ham tended to increase in size in proportion to shoulder and middle, the proportion of lean meat in the side increased. No consistent relationship was obtained between back fat measurements and percentage of lean. Correlations were calculated between percentage "eye of lean" and carcase measurements. A high positive correlation (+ .95) was found between the percentage "eye of lean" and the percentage of ham. In other words, the better the ham, the larger the "eye of lean," and there was more extensive muscling in the cross sections which were studied.

In conclusion, the authors state that the importance of feeding and management practices in relation to the quality of the finished article must not be overlooked, but when consideration is given to the variability which occurs among closely related pigs similarly managed, the importance of the breeding aspect becomes clearly manifest.

A.D.B.S.

Beef Breeders Working on the Right Lines?; Are

W. A. Stewart (Northants Inst. Agri., Moulton). (1936). *Fmrs' Weekly*, 5 (28), 27, 2 figs.

The importance of milking capacity in the cows of beef breeds is illustrated by observations made at the Thomas Harrison Farm of the Northamptonshire Institute of Agriculture. The best calves at weaning time were not necessarily out of the cows of best conformation, but clearly the calves out of the best milkers. With reference to the increasing practice of using foster-mothers, the opinion is expressed that the use of bulls reared on nurse cows necessarily tends to lower the milking standard of the breed.

A.D.B.S.

Beef Cattle; A Method of Measuring Performance in

W. H. Black and B. Knapp. (1936). *Proc. Amer. Soc. An. Prod.*, 72-7.

A report on the method employed by the U.S. Department of Agriculture Bureau of Dairy Industry at Beltsville. Some interesting correlations are given. Particularly interesting is the fact that the average daily gain from birth to weaning and from weaning to slaughter are negatively correlated, which shows that animals which grow at a greater rate while on milk tend to gain at a slower rate thereafter. There was no correlation between economy of gain from birth to weaning and

economy of gain from weaning to slaughter This is probably due to the fact that during the period prior to weaning there are many uncontrolled variables affecting economy of gain, while during the period subsequent to weaning the actual growth and fattening abilities can be studied with accuracy because conditions are practically constant.

Gain from birth to weaning was rather highly correlated with pounds of milk received during this period.

Grade of animal shows a higher correlation with economy of gain than with average daily gain, but both are significant.

The writers conclude that percentage of edible portions seems to be a good measure of beefiness. Tenderness was found to be correlated with percentage of fat. There are also figures on costing, and details are given of progeny testing for beef cattle. A.D.B.S.

Butterfat Production in the First Live Lactations; The Relation of Age at First Calving to

A. B. Chapman and G. E. Dickerson. (1936). *Proc. Amer. Soc. An. Prod.*, 52-5.

Early calving does not appreciably decrease average monthly production, but the average difference in production at seven years of age between a cow calving first at 24 and another at 34 months of age is about 800 lbs., and therefore the early calver has an added advantage in yield, as well as of producing approximately one more calf. The period from the first calving to seven years of age in the early calvers being longer than that from cows calving at a later age does more than compensate for the effects of less maturity during the first few lactations.

The paper is not conclusive, but does point to a tendency in favour of early calving. A.D.B.S.

Colour Inheritance in Shorthorn Cattle.

E. Roberts. (1937). *J. Hered.*, *28*, 167-8.

This paper is based upon an exact analysis of the colour of calves born in the Shorthorn herd of the University of Illinois over a period of thirty-three years. The results fit closely to the theory of a single factor inheritance in which red and white are homozygous, and roan is heterozygous. A.D.B.S.

Conformation and Anatomy of 593 Dairy Cows having Records of Production; Variations Recorded in the Study of the

W. W. Swett, C. A. Matthews, F. W. Miller and R. R. Graves. *U.S. Dept. Agri.*, BDIM-589 Revised.

Since 1923 the United States Department of Agriculture Bureau of Dairy Industry has, with the co-operation of nineteen agricultural experiment stations, accumulated data on ante-mortem and post-mortem measurements of the dairy cow with a view to determining the value of external body measurements as an index of production and as an extension of a knowledge of the physiology of milk secretion. This is an interim report, but when the data are available for a sufficient number of cows by breeds to justify statistical analysis it is expected that the significance of type as an indicator of producing ability in dairy cows will be determined and that a more nearly scientific basis for judging dairy cattle will result.

No attempt is made to draw conclusions, the summary being prepared for the information and guidance of those co-operating in the project and for the benefit of any interested in the study of the conformation and anatomy of the dairy cow. A.D.B.S.

Genetic History of Hereford Cattle in the United States; A

O. S. Willham. (1937). *J. Hered.*, *28*, 288-94

Samples of Hereford cattle in the United States were taken at ten-year intervals from 1870-1930. Each sample consisted of 250 bulls and 250 cows chosen from recorded calves born in the year in question. The co-efficient of inbreeding rose to 8.1 per cent. in 12.9 generations from 1860-1930.

In 1930 the *inter se* relationship in the breed was 8.8, which would result from an inbreeding coefficient of about 4.6 if random mating had been practised. The higher coefficient of inbreeding indicates a tendency towards the formation of separate families, but this tendency rarely progresses, being held in check by crosses between families. Nearly all the animals which had unusually high relationships were either the ancestors, descendants, or mates of Anxiety 4th. Special groups of prizewinning and Register of Merit animals had higher coefficients of inbreeding and *inter se* relationship.

The average interval between generations was 5.4 years. Twenty English breeders were responsible for the breeding of the foundation animals, in which ended over 80 per cent. of the random ancestral lines traced in this study. Three of them bred 38 per cent. of the foundation animals in the 1930 sample. Wright's short method was used.

A.D.B.S.

Genetics of Dairy Cattle; Biennial Review of the

A. D. Buchanan Smith. (1937). *J. Dairy Res.*, *8*, 131-42.

This covers the work which has been published during the past two years, and deals with measures of inheritance of total yield and its relation to fat production. There are also sections dealing with butterfat and other constituents of the milk, the relation of conformation to production, the efficiency of production, methods of improvement, and tropical dairy cattle. A.D.B.S.

Impacted Molars—A New Lethal in Cattle.

E. E. Heizer and M. C. Hervey. (1937). *J. Hered.*, *28*, 123-8.

This abnormality occurred in a herd of Dairy Shorthorn cattle in central Ohio. The calves were of normal size and born alive, but died within the first week after parturition. The principal abnormality was the impaction of the premolar teeth in the mandible, which was greatly reduced in length and width, giving a " parrot-mouth " appearance. The abnormality is described in detail.

The incisor teeth were normal, the upper jaw normal, and gross examination revealed no pathological conditions in other parts of the body.

Defective calves occurred as the result of close inbreeding The authors consider the abnormality to be inherited as a simple recessive.

A.D.B.S.

Inheritance of Milk Yield in three herds of Dairy Shorthorn Cattle; A Statistical Enquiry into the

A. D. BUCHANAN SMITH. *J. of Dairy Res.*, Vol. VIII, No. 8 (Oct., 1937).

The investigation of the inheritance of milk yield has engaged the attention of many workers in all parts of the world for a considerable time. In 1928 Buchanan Smith opened up a new field when he called attention to the fact that inheritance of milk yield is probably partly dependent on the action of sex-linked genes (factors). The present paper summarises the result of previous work, and gives an account of a further investigation with three large herds of Dairy Shorthorns. In two of the herds a significant result was obtained, but the figures for the third herd did not agree with the other two. It is, therefore, admitted that the present studies have not given a conclusive answer to the general question. Still the results definitely show that an unexplained factor exists, and although the original suggestion was made nine years ago, other workers have not been able to produce any direct evidence against the theory. The paper gives a valuable review of the whole subject and is of great interest to all breeders of dairy cattle.

R. G. W.

Management and Breeding Data on a Dairy Herd in which Bang's Disease (Infectious Abortion) was Eradicated by Segregation.

F. W. MILLER, R. R. GRAVES, and M. H. FOHRMAN. (1937). *J. Dairy Sci.*, 20, 537-50.

Contagious Abortion interfered considerably with the experimental work conducted by the United States Bureau of Dairy Industry, and in 1926 it was decided to divide the herd into two groups, the abortion-positive animals being moved to new buildings half a mile from where the abortion-negative cows were held, and looked after by separate attendants. Manure from the abortion-positive group was taken to cultivated fields only; the calves born were taken to the home farm as soon as convenient, usually at about 50-60 days old, up to which time they received the milk from the abortion-positive group; after ten days isolation they were added to the abortion-negative group. There was no evidence of abortion disease being spread by this method.

The bulls were kept with the abortion-negative group, and mated to abortion-positive cows on neutral ground. The cows in both groups were mated with the same bulls which were not treated or disinfected in any way before or following matings. No evidence was obtained of the spread of abortion disease by this manner of mating. The abortion-positive cows required more services for a conception, and the percentage of conceptions resulting from the first four services was smaller in this group than in the other, as also was the percentage of pregnancies terminating in live calves

Originally there were 65 cows of breeding age in the abortion-positive group, and to this was added, from 1926 to 1932, 80 cows from the abortion-negative group that had contracted the infection. It was these 80 cows from the abortion-negative group that showed definitely the poorest breeding efficiency, due to the fact that they became positive and went through the most serious phase of the disease during the period covered by the figures, while many of the animals in the original positive group had already passed through the most serious phases prior to the segregation.

Figures are given of the sex of the calves. In the initial negative

group there were 94 heifers to 90 bulls, compared with the initial positive group of 106 heifers to 138 bulls. The 80 cows transferred from the negative to the positive group gave 100 heifers to 106 bulls.

A.D.B.S.

Milk Fever; The Occurrence of—in the Kentucky Station Herd over a Period of Twenty Years.

H. J. Metzger and H. B. Morrison. (1936). *Proc. Amer. Soc. An. Prod.*, 48-52.

These results are based on 218 cows of Jersey, Holstein and Guernsey breeds which were maintained and housed as one herd. No milk fever occurred at the first calving, but the data show that cows become susceptible with the second, and this susceptibility increases up to the fifth or sixth, and that many of the cows showed a tendency to have more than one case, this being particularly marked in the Jerseys, which had a greater tendency than the other breeds. Milk fever is definitely associated with high milk production.

A study of the pedigree failed to give evidence to enable one to say that the tendency to have milk fever is inherited. The author points out that as one breed showed an increased susceptibility, and the fact that milk fever occurs most often in high producing cows, points to the possibility that it may be an inherited tendency.

The occurrence of milk fever may also depend upon the month of calving and general climate of the year. A.D.B.S.

Milk Yield in Cows; The Lactogenic Preparations from the Anterior Pituitary and the Increase of

G. J. Asimov and N. K. Krouze. (1937). *J. Dairy Sci.*, 20, 289-306.

The authors have carried out numerous tests on large numbers of cows (over 2,000 head) with a view to determining the value of the injection of an extract of anterior pituitary of cattle (method of preparing prescribed) as a means for increase of milk yield. All cows, with few exceptions, reacted by an increase of the milk yield after each injection of the preparation.

The paper also reports an investigation into the possibility of the practical application of lactogenic substances from the hypophysis.

A single injection to 372 cows, and a repeated injection to 138 cows resulted in an increase of 7,675 litres of milk in a couple of days. The quality of milk remained normal. The percentage of butterfat slightly increased in a certain number of cases.

Tests with the lactogenic preparation of the hypophysis have proved the harmlessness of these injections and the absence of any undesirable after-effects. The injection of this substance is more effective in cattle in good condition and during the first half of the lactation.

There is a discussion on the physiological implications of this work.

A.D.B.S.

Mortality of Calves in the Iowa State College Dairy Herd.

J. Ingels and C. Y. Cannon. (1936). *Proc. Amer. Soc. An. Prod.*, 223-9.

The records of the Iowa State College dairy herd were examined from 1907. The sex ratio for the herd is 112 males per 100 females, while of first calves it is 123 males per 100 females. 8.8 per cent. of the females born were born dead, 14.4 per cent. died between birth and before first calving. Thus over 22 per cent. of all females born failed

to reach a point where they could be used for replacement purposes in the milking herd.

After sales, which occurred at from 19 months of age to first calving, slightly over half of the heifer calves born entered the milking herd. The writers consider this to be a meagre margin on which to supply replacement needs. A.D.B.S.

Oestrous Cycle; On the Change Over in the—in Animals after Transference across the Equator, with further Observations on the Incidence of the Breeding Seasons and the Factors Controlling Sexual Periodicity.

F. H. A. MARSHALL. (1937). *Proc. Roy. Soc. Lond.*, Series B., *122*, 413-28.

An extension of the previous paper, discussing in particular the sexual periodicity of animals transferred across the equator. Sheep and red deer adjust themselves to the new cycles. The change-over may begin at once, so that the animals may have two sexual seasons in the year of transfer. The complete adjustment may take about two years. Emphasis is laid on the fact that, whereas with most animals light appears to enhance sexual activity, there is a great variation in the reactions of different species, and that it is unsafe to generalize from results obtained from one species of animal. A.D.B.S.

Persistency of Production in Jersey Cows and its Practical Application.

L. COPELAND. (1937). *J. Dairy Sci.*, *20*, 151-8.

The difficulty which confronts anyone attempting to study the question of persistency of production in cattle lies in the difficulty of evolving a single numerical figure which may be taken to express persistency. To avoid this difficulty, the author has selected groups of cows in what are known as the Class A group of the official Register of Merit of the American Jersey Cattle Club. These all had lactations extending to 365 days. Cows with shorter records were excluded to eliminate influence due to advanced pregnancy Twenty cows which had completed records of over 1,000 lbs. of butterfat formed the first group, while the second consisted of similar cows which failed to meet the minimum Register of Merit requirements, and could therefore be called "low record cows." The third group consisted of cows calving with the same interval, but with shorter lactations. For each cow records were divided into twelve periods of thirty days each, discarding the last five days of each lactation. From these yields the percentage of the total 360 day production produced in each thirty day period was determined. The percentages were then charted.

The results show that the total production for a lactation period gives some indication regarding persistency, since the high producing cows were, in the great majority of cases, much more persistent than were the extremely low producers.

Maximum yield of milk or butterfat after calving does not give much information regarding persistency. Cows with the same initial rate of yield varied greatly in persistency. Cows with a low total production reached their maximum rate of yield earlier in the lactation than did cows with a high total production.

The author concludes that persistency appears to be an inherited character, and persists throughout the lifetime of a cow. If a first calf

heifer shows, under normal conditions, an inability to milk for at least eight or nine months, the chances appear against her developing into a profitable cow during later lactations.

A.D.B.S.

Piglings; Observations on Rearing

K. Hugenroth. (1937). *Dtsch. landw. Tierz.*, *41*, 164-5.

Records of six sows tend to confirm the observation that the teats neglected by the first litter are utilised by the weakest piglings of subsequent litters. Such piglings never attain the weight of their litter mates. The teats do not give a normal yield, and deficient sows should be culled. Uniformity of teat development and of litters should be made the basis of selection. Previous observations are confirmed as regards individual constancy of preference for a particular teat following a few days' changing of teats. It is possible to correlate the number of the teats suckled and the weekly gain in weight of the pigling.

A.D.B.S.

Pigs; Suckling and Suckling Preference in
Suckling Pigs; The Milk Consumption and Growth of

H. P. Donald. *Empire J. Expt. Agri.*, Vol. V, No. 20.

The two papers give an account of investigations carried out at Edinburgh on young pigs. Pigs are reared in litters and cannot under normal conditions be fed individually before weaning. It is therefore necessary to obtain the fullest possible information regarding variations in the milk supply during the suckling period as a preliminary to the study of the development of young pigs.

The first paper describes an investigation into the effect of the well-known preference of each pig of a litter for "its own teat," and careful observations were also made on the process of suckling generally.

The second investigation showed a close association between the live weight increase and the amount of milk consumed. One sow, which was nursing ten pigs in her third litter, gave over 80 per cent. more milk than another sow which had twelve pigs in her first litter. In general, the largest pigs obtained the most milk, but appear to have converted it to live weight increase less economically than their smaller litter mates. As the interval between sucklings lengthened, the amount of milk obtained by each pig increased. For one of the sows, the actual production for each nipple could be ascertained and showed great irregularity. The anterior nipples tended to be more productive than the posterior.

R.G.W.

Pigs; Weaning Weight and Litter Sampling with Reference to Litter Size.

A. D. Buchanan Smith and H. P. Donald. *J. Agri.* Sci. Vol. XXVII, Part iv. (1937).

Two questions were dealt with in the investigations described in this paper:—

(*a*) The relationship between weaning weight and litter size.

(*b*) The method of litter sampling for the purposes of litter testing.

The following are the chief conclusions arrived at:—

1. No general relation exists between the weight at weaning and the size of the litter.

2. A correlation of .96 was found between the mean growth rate of samples consisting of all the four pigs nearest the average at weaning and the mean of the whole litter.

3. Individual weight at weaning would appear to be of slight value in estimating subsequent performance. R.G.W.

Range Ewes; The Rate of Breeding and Lambing and the Length of Gestation Period of

D. W. CHITTENDEN and A. H. WALKER. (1936). *Proc. Amer. Soc. An. Prod.*, 282-6.

The rate of breeding of range ewes is greatest during the first week of the breeding season, followed in order by the second, third and fourth weeks. The range ewes, mated to Hampshire rams, bred at a more rapid rate than when mated to Rambouillet rams.

The gestation period for range ewes averages 149.64 days; when mated to Hampshire rams the gestation period is about two days shorter than when mated to Rambouillet rams. Thus the breed of the rams has an influence on the gestation period. A.D.B.S.

Sexual Periodicity and the Causes which Determine It.

F. H. A. MARSHALL. (1936). *Phil. Trans. Roy. Soc. Lond.*, Series B, *226*, 423-56.

A paper which shows that in nearly all animals breeding phenomena occur in response to seasonal change, and in the vast majority (but not all) the principal stimulus is increase of light. Changes in temperature and food generally play a part in determining the sexual cycle. This fact is well appreciated by poultry breeders, and the writer quotes information from Dr. Hammond showing that there is a definite tendency for foaling to occur in spring, and discusses this in relation to different parts of the world. In sheep the usual sexual season is autumn, as also with deer. In the southern hemisphere their breeding season is in actual time the reverse.

The author concludes that there is an internal rhythm of reproduction depending primarily upon the alternation of periods of rest and activity. In the higher animals this internal season is brought into relation with seasonal changes and other environmental factors which condition the metabolic process, but also acting exteroceptively through the nervous system, and probably through the anterior pituitary. They also affect the testis or ovary, through the nervous system and probably through the anterior pituitary. A.D.B.S.

Sheep Breeding in the Arable Areas; Recent changes in (I)

R. P. ASKEW. (1937). *J. Min. Agri.*, *44*, 450-7.

Sheep Breeding in the Arable Areas; Recent Changes in (II)

R. P. ASKEW. (1937). *J. Min. Agri.*, *44*, 562-71.

In 1867 the total number of sheep in England and Wales was over 22 million, a figure which declined steadily to 1920, when it was over 18 million, but there has been a subsequent increase to 18.5 million in 1932. From the fact that there has not been a corresponding decrease in the number of ewes, the drop may be largely accounted for by an increase in the sales of lambs with a shorter average life.

The paper deals with the changes from the arable to the grass type, and in the second part comparative figures are given of registered flocks of the four Down breeds, all of which have shown a decline in England

and Wales. The Suffolks, by reason of their present popularity in Scotland, have increased in the British Isles by 38 per cent.

There has been a considerable change in the distribution of the breeds. For instance, in 1910, the Suffolks were almost entirely in the arable areas, and at that time in Suffolk there were 154 flocks, a figure which has now dropped to 68.

The author emphasizes the distinction between breeding to obtain rams and ewes for stock purposes and breeding for commercial production of mutton and lamb. This brings him to the question of the crossbred. Before the war, both Southdowns and Hampshires were kept pure for commercial production, but in recent years there appears to have been a decline in the commercial use of purebreds, and the practice of cross-breeding is more widespread, more complex, and less systematic than it was twenty-five years ago. He states that, while the Scottish farmer decided fifty years ago what was the most suitable sheep for his farming, the English farmer is still struggling in a confusion of breeds.

He stresses specialization in production, and is of opinion that the prospects are not good for the long-wool breeds. He states that the choice between breeds must be made on a balance of advantages. What these are has been a matter for experiment. Certain breeds have little future in commercial production, and arguments for a measure of standardisation in breeding must eventually carry some weight.

A.D.B.S.

Stringhalt in the Horse; The Inheritance of

V. A. Scekin. (1937). *Konevodstvo*, No. 2, 20-26.

An analysis of the known cases of stringhalt among Orlov trotters leads the author to the assumption that the condition is encountered only within definite blood lines. A more detailed analysis of several pedigrees of affected animals points to the fact that stringhalt is met with only when it is found on both sides of the pedigree, though often there is a skipping of generations. This points to the recessive nature of this hereditary defect. Only two cases are recorded where both parents have been affected. In both these cases the offspring also were affected. Out of eleven matings where one parent was affected and the other was out of an affected line, six offspring were affected with stringhalt, five were not. Out of sixteen matings where both parents were externally normal though of known affected descent, there were four affected and twelve normal offspring. Out of thirty-seven matings where only one parent was of affected descent, all the thirty-seven offspring were externally normal. It is concluded that stringhalt has a monogenic basis.

A.D.B.S.

Vaginal Secretion and the Sex of the Progeny in Sheep.

M. K. Kardymovic. (1936). *Biol. Z. (Mosk.)*, 5, 915-24.

Observations were made on 638 ewes with 832 lambs in an attempt to establish the correlation between the pH of the vaginal secretion and the sex of the progeny. Ewes with a pH of below 5.5 produced only 33.3 per cent. of ewe lambs, while, as alkalinity increased, the proportion of females rose, reaching 85.7 per cent. at a pH of 7.75 or higher; the extreme classes are small, but if several are grouped together, the range is still wide, *viz.*, 40.9 ± 4.28 per cent. and 59.7 ± 4.40 per cent. of females at pH of below 6 and 7.25 respectively. The same results were obtained when the ewes were inseminated naturally (into the vagina) or

artificially (into the cervix). An attempt to produce a shift of the pH of the vaginal medium by diluting the sperm or by washing out the vagina prior to mating with acid or alkaline solutions (lactic acid, sodium bicarbonate) did not affect the sex ratio. It is thought that the differentiation of the X- and Y-bearing sperm does not occur in the vagina but in some other part of the genital tract, and the pH of the vaginal secretion is merely an index of the general state of the organism. It was previously found that the pH varies with the progress of oestrus, being more alkaline at the beginning and progressively more acid towards the end. It appears probable that insemination of ewes at early stages of oestrus will lead to an increased production of ewe lambs.

A.D.B.S.

SOILS AND MANURES.

Abstractors:

Professor T. W. Fagan, M.A., F.I.C., University College, Aberystwyth,
and
Professor G. W. Robinson, M.A., University College, Bangor.

Mother Earth, being letters on soil addressed to Professor R. G. Stapledon, C.B.E., M.A., by G. W. Robinson, Sc.D., Professor of Agricultural Chemistry, University College of North Wales, Bangor.

19 x 14. pp. 210. Maps., plts. London: Thomas Murby & Co. (1937). 5/6.

The book consists of seventeen letters, and in the first of these the author points out that they are to be looked upon as a series of essays on topics relating to soil viewed from a philosophical standpoint.

They are written mainly for workers in such fields as Geology, Geography, Ecology and Agronomy, with the purpose of furnishing them with that knowledge of soils that will be of assistance to them in their own studies. From one of such ripe experience as the author and one also who has so much first-hand information of the subject gained in his own research work and wide travel, the letters could not fail admirably to fulfil their purpose.

The earlier letters deal with *soil* as a material and *a soil* as a natural body or individual in the field. The limits of information obtained from an examination of soil as a material are clearly defined and contrasted with that obtained from a study of the soil profile, that is, the medium in which plants grow.

The soil material, both inorganic and organic, is fully discussed and the importance of the finer particles forming clay of different types and of the organic matter as humus is emphasized. The association of clay with humus forming the colloidal complex in the soil, and the difference in effect of this complex on the physical and chemical properties of the soil when present as a weak acid compared with its effect when saturated with bases, is simply but very clearly explained.

Soil profile forms the main theme running through the majority of the letters, and an excellent photograph of a typical podzol profile, illustrating its characteristic horizons, is included. The factors responsible for the formation of these horizons as well as those of other profiles are discussed in a manner that the veriest tyro can understand.

In a most interesting letter on soil surveys and the preparation of soil maps the author draws on his own extensive research work in Wales to illustrate how the former are undertaken and the latter prepared. He has found it convenient to make a preliminary classification of soils into suites, that is, soils derived from the same or similar material, and to subdivide these into series according to the mode of development as shown in the profile. A soil map is included indicating the data gathered in the field and the manner in which these are recorded. In the field, six inch to the mile Ordnance survey maps are used, and from these more generalized maps on a smaller scale are prepared. A map of the soils of Anglesey prepared in this way forms the frontispiece.

In other letters soil moisture, fertility, manures and lime are each thoroughly discussed, and that without any ambiguities. The last five letters are devoted to "Forest, grass and arable land," "Our agricultural soils," "Waste lands," "The corruption of the best is the worst of all," and "Concluding reflections." Each of these letters has its message, as have all in the series, and each is written with clearness and elegance.

The clear and lucid manner in which the whole story of the soil is told in these letters will doubtless encourage many to turn to the author's larger book on soils who had previously found their knowledge of Chemistry and Physics inadequate for the full appreciation of this standard work.

The one regret felt by the reviewer after reading the letters is that they were not longer or more in number, but perhaps Professor Robinson's counsellors will prevail upon him to write a similar series of letters at a future date. T.W.F.

Weathering; The Cycle of

B. B. POLYNOV. Translated by Alexander Muir. Pp. 220 + xii. London: Thomas Murby & Co. 10/6 net

This work by a distinguished Russian pedologist is concerned principally with the "crust of weathering" and the weathering cycle. It is of interest to students of the soil because soils are formed from the products of rock weathering. Prof. Polynov's ideas represent a certain reaction from the classical school of Docuchaiev and Glinka, according to which each climate has its own type of soil formation. According to Polynov, the observed climatic soil types merely represent varying stages of development in the same weathering cycle. The book is fortunate in its translator, Dr. Muir, who is a former student of Prof. Polynov and therefore competent to interpret his views to English readers. G.W.R.

AGRICULTURAL BOOKS, 1937.

The following list, prepared by the staff of the National Library of Wales is a selection of the more important books on the science and practice of agriculture published during the year 1937, together with a few omitted from the List for 1936. The list supplements *The Hand List of Books on Agriculture* issued by the National Library, third edition, 1926, copies of which can be obtained on application to the Librarian, The National Library of Wales, Aberystwyth.

AINSWORTH, G. C. The Plant diseases of Great Britain: a bibliography. London: Chapman & Hall, 1937. pp. xii, 274 ... ... 15s. 0d.

ARMSTRONG, S. F. British grasses and their employment in agriculture . . . *3rd ed.* Cambridge University Press, 1937. pp. xii, 350. ill., bibl. 15s. 0d.

AUCHTER, E. C., *and* KNAPP, H. B. Orchard and small fruit culture . . . *3rd ed.* New York: Wiley, 1937. pp. xxii, 628, ill., bibl., diags. ... 25s. 0d.

BENJAMIN, E. W., *and* PIERCE, H. C. Marketing poultry products . . . *3rd ed.* New York :Wiley, 1937. pp. xii, 402, pls., ill., diags., bibl. ... ... 20s. 0d.

BORG, J. Cacti . . . London: Macmillan, 1937. pp. xii, 420. front., ill., bibl. ... ... 21s. 0d.

BOYS, *Sir* C. V. Weeds, weeds, weeds. London: Old Westminster Press, 1937. pp. 72 ... ... 1s. 0d.

CHEVELEY, S. W. Grass drying. London: Ivor Nicholson & Watson, 1937. pp. 128. front., pls. ... 6s. 0d.

COFFEY, W. C. Productive sheep husbandry . . . *3rd ed. rev.* by W. F. Kammlade. Chicago: Lippincott, 1937. pp. xxxii, 480. col. front., ill. 12s. 6d.

COX, J. F., *and* JACKSON, L. E. Crop management and soil conservation. New York: Wiley, 1937. pp. xviii, 610. ill., bibl. ... ... 18s. 6d.

ECKLES, C. H., *and others.* Milk and milk products . . . By C. H. Eckles, W. B. Combs, and H. Macy. *2nd ed.* New York: McGraw-Hill, 1936. pp. xiv, 386. ill., diags. ... ... $3.50.

ELLIS, J. C. B. The Feeding of farm live stock. London: Crosby Lockwood, 1937. pp. 292. pls. ... 15s. 0d.

FRASER, Allan. Sheep farming. London: Crosby Lockwood, 1937. pp. 178. front., pls. ... 7s. 6d.

HALL, *Sir* A. D. The Feeding of crops and stock . . . *2nd ed.* London: John Murray, 1937. 3 vols. ill., diags., bibl. ... ... 3s. 0d. each vol.

HAWLEY, R. C. Forest protection. New York: Wiley, 1937. pp. x, 262. bibl. ... ... 18s. 6d.

The Practice of Silviculture with particular reference to its application in the United States of America . . . *4th ed.* New York: Wiley, 1937. pp. xiv, 252. diags., bibl. ... ... 15s. 0d.

HILL, A. F. Economic botany . . . New York: McGraw-Hill, 1937. pp. x, 592. ill., diags., bibl. ... $4.00.

HUTCHESON, T. B., *and others.* The Production of field crops. New York: McGraw-Hill Book Co., 1936. pp. xviii, 446. front., ill., maps, bibl., diags. 21s. 0d.

KNOWLES, F., *and* WATKIN, J. C. A Practical Course in agricultural chemistry . . . London: Macmillan, 1937. pp. x, 188. ill., diags. ... ... 10s. 0d.

McDOWELL, J. C., *and* FIELD, A. M. Dairy enterprises. Chicago: Lippincott, 1936. pp. viii, 472. col. pls., ill., bibl ... ... 10s. 6d.

MASSEE, A. M. The Pests of fruit and hops. London: Crosby Lockwood, 1937. front., pls., bibl. ... 15s. 0d.

MILLER, W. C., *and* ROBERTSON, E. D. S. Practical animal husbandry. *2nd ed. rev. and enl.* Edinburgh: Oliver & Boyd, 1937. pp. xii, 432. front., pls., ill., bibl., diags. ... ... 15s. 0d.

MOON, F., *and* BROWN, N. C. Elements of forestry . . . *3rd ed. rev.* New York: Wiley, 1937. pp. xviii, 398, front., ill., bibl. ... ... 17s. 6d.

OXFORD: *University. Agricultural Economics Research Institute.* Egg prices . . . By O. J. Beilby. Oxford: The Institute, 1937. pp. 66. ... 2s. 6d.

Grass drying . . . By R. N. Dixey and R. P. Askew. Oxford: The Institute, 1937. pp. 46. 1s. 0d.

Mechanized corn growing . . . By A. Bridges and E. P. Weeks. Oxford: The Institute, 1937. pp. 68. ... ... 2s. 6d.

Milk consumption, by K. A. H. Murray. Oxford: The Institute, 1937. pp. 64. ... ... 2s. 6d.

Milk Investigation Scheme. Costs of milk production in England and Wales. Interim Report No. 1. . . . Oxford: The Institute, 1937. pp. 88. ... ... 2s. 6d.

Milk marketing before and after organization: a study in Central Somerset, by B. L. Smith and H. Whitby. Oxford: The Institute, 1937. pp. 56. ... ... 2s. 0d.

Tuberculin tested milk . . . By R. N. Dixey. Oxford: The Institute, 1937.

ROBINSON, D. H. Leguminous forage plants. London: Edward Arnold, 1937. pp. viii, 120. ill. ... 6s. 0d.

RUSSELL, *Sir* E. J. Soil conditions and plant growth . . . *7th ed.* London: Longmans, 1937. pp. viii, 656. front., pls., diags., bibl. ... ... 21s. 0d.

SMITH, K. M. A Textbook of plant virus diseases. London: Churchill, 1937. pp. x, 616, front., col. pl., ill., diags., bibl. ... ... 21s. 0d.

STEBBING, E. P. The Forests of West Africa and the Sahara: a study of modern conditions. London: Chambers, 1937. pp. viii, 246. pls., ill., maps. 15s. 0d.

STUART, W. The Potato . . *4th ed. rev.* Chicago: Lippincott, 1937. pp. x, xvi, 508. col. pls., ill., bibl. ... ... 12s. 6d.

TOUMEY, J. W. Foundations of silviculture upon an ecological basis . . . *2nd ed. rev.* by C. F. Korstian. NewYork: Wiley, 1937. pp. xxii, 456. ill., bibl. ... ... $4.50.

WALLACE, H. A., *and* BRESSMAN, E. N. Corn and corn growing . . . *4th ed. rev.* New York: Wiley, 1937. pp. viii, 436. ill. ... ... 18s. 6d.

WATSON, J. A. Scott-, *and* HOBBS, M. E. Great farmers. London: Selwyn & Blount, 1937. pp. 288. front. (port.), pls. ... ... 12s. 6d.